

The Middle Triassic Megafossil Flora of the Basin Creek Formation, Nymboida Coal Measures, New South Wales, Australia. Part 5. The Genera *Lepidopteris*, *Kurtziana*, *Rochipteris* and *Walkomiopteris*.

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Leaves attributed to the gymnosperm genera *Lepidopteris*, *Kurtziana* and *Rochipteris* and the leaf sedis incertae *Walkomiopteris eskensis* (Walkom) Holmes and Anderson gen. et comb. nov. are described from two quarries in the Basin Creek Formation of the Middle Triassic Nymboida Coal Measures. Based on extensive collections of leaves, the morpho-genera *Lepidopteris* and *Kurtziana* each reveal a wide range of variation. *Lepidopteris* is divided into three 'morpho-species complexes' with intergrading forms based on *L. madagascariensis*, *L. africana* and *L. stormbergensis* and a new species *L. dissitipinnula* apparently without links to the three complexes. The *Lepidopteris* fertile organs, *Peltaspermum* and *Antevsia* are present. *Kurtziana* is separated into two 'morpho-species complexes' based on *K. brandmayri* and *K. cacheutensis*. *Rochipteris* is a diverse genus but of very rare occurrence. Six new species are described; *R. obtriangulata* and *R. tubata* display a close-spaced spiral or whorled arrangement. Seven leaves of *R. incisa* have been examined. *R. sinuosa*, *R. pusilla* and *R. nymboidensis* are represented by single dispersed leaves. *Walkomiopteris eskensis* (Walkom) gen. et comb. nov. is redescribed from additional Nymboida material.

KEYWORDS: *Kurtziana*, *Lepidopteris*, Middle Triassic Flora, Nymboida Coal Measures, *Rochipteris*, *Walkomiopteris*.

INTRODUCTION

In this fifth part of a series describing the early middle Triassic Nymboida flora, leaves assigned to three gymnosperm genera: *Lepidopteris* with some associated fertile organs, *Kurtziana*, *Rochipteris* and the new genus *Walkomiopteris* sedis incertae are illustrated and described.

Part 1 (Holmes 2000) of this series dealt with the Bryophyta and Sphenophyta, Part 2 (Holmes 2001) with the Filicophyta, Part 3 (Holmes 2003) with fern-like foliage and Part 4 (Holmes and Anderson in press) with the genus *Dicroidium* and its fertile organs *Umkomasia* and *Pteruchus*.

The material described below is based mainly on the collections made by the senior author and his

family from two Nymboida quarries over a period of almost forty years. Details of the Coal Mine Quarry and the Reserve Quarry together with a summary of the geology of the Basin Creek Formation, the Nymboida Coal Measures and the Nymboida Sub-basin were provided in Holmes (2000).

METHODS

In living populations of extant plants there is often a large range of variation in leaf shape, e.g. juvenile, adult, shade, sun-leaves, etc. A preserved holotype in a herbarium seldom exhibits this range of variation. It is only through wide experience in the field that this variation can be recognised and appreciated. In the fossil record, leaves constitute the vast majority

of preserved plant organs. Most early palaeobotanical taxonomy was based on very limited material in the field or a few museum specimens. Original diagnoses rarely acknowledged the variation that could occur in a 'natural' species. To compound the problem of separating fossil leaves into 'natural' species, the assemblages from one locality may represent vegetation from a range of habitats and growing through an unknown period of time. As in Part 4 of this series, which dealt with the highly variable morpho-genus *Dicroidium* (Holmes and Anderson in press), we address the problem of variability observed in the large collections of *Lepidopteris* and *Kurtzia* leaves by creating 'species complexes'. A 'species complex' includes leaves displaying a range of variation centred on a previously-described species. Intergrading forms often link the 'complexes'. The Selected References are of specimens we consider to represent a mid-range for each 'species complex'. Leaves illustrated in the Figures should enable comparisons to be made with material from other locations and horizons. Leaves in the genera *Rochipteris* and *Walkomiopteris* are represented respectively by ten and six specimens only, so are placed in morpho-species based on gross morphology of the material available.

At the Nymboida quarries most specimens are preserved as carbonaceous compressions in which the gross morphology is usually well-preserved. However, spores and cuticles have been destroyed by a tectonic heating event during the Cretaceous Period (Russell 1994).

Type and illustrated material is housed in the Australian Museum, Sydney. Some additional specimens are in the collections of the Geology Department, University of New England, Armidale, NSW, and the type of *Walkomiopteris eskensis* is housed in the collections of the Queensland Museum, Brisbane.

SYSTEMATIC PALAEOBOTANY

Ginkgoopsida S.V.Meyen 1987

Peltaspermales F. Nemejc 1968

Peltaspermaceae H.H. Thomas ex T.M. Harris 1937

Genus *Lepidopteris* Schimper 1869

Type species *Lepidopteris stutgardiensis* Schimper 1869

The proposal by Poort and Kerp (1990) to unite the leaves of *Lepidopteris 'natalensis'* with the ovulate organ *Peltaspermum thomasi*, which occur together at the Waterfall locality in the Molteno Formation (locality Umk111 of Anderson and Anderson 1983),

in the 'natural genus' *Meyenopteris* is untenable. The leaf species *Lepidopteris stormbergensis* has priority over *L. natalensis*. An additional leaf and ovulate species have been described from the same Umk111 locality (Anderson and Anderson 2003). Until fruit, leaves and stems are found in organic connection, it is premature to erect a 'natural genus'. In accordance with ICBN (2001) Articles 1.2 the morpho-genus *Lepidopteris* should be retained for dispersed leaves and the morpho-genera *Peltaspermum* and *Antevsia* for the dispersed female and male organs respectively.

Leaves of the *Lepidopteris* genus occur in the Permian of the Northern Hemisphere. The first Gondwanan record is of *L. callipteroides*, a branched leaf form from the basal Narrabeen Group (earliest Triassic), of the Sydney Basin (Retallack 2002). This species apparently did not persist through to the Middle Triassic. For many Gondwanan *Lepidopteris* leaves the application of specific names has at times been questionable. Some species are known only from impressions while some, with better preservation have been described with cuticle information (Carpentier 1935; Townrow 1960, 1966; Baldoni 1972; Baldoni and de Cabrera 1977; Anderson and Anderson 1989). However, as noted by Townrow (1966), there are problems of identification of specimens both with or without cuticle. Rigby (1977) suggested reserving the name *L. stormbergensis* for all leaves lacking cuticle and *L. natalensis* and *L. madagascariensis* for those with preserved cuticle, while Retallack in Retallack et al. (1977) argued that the diverse range of leaves from the Cloughers Creek Formation in the Nymboida Coal Measures was best placed in *L. madagascariensis* on the basis of the thick leaf substance and mostly obtuse pinnules although no cuticle was present. We regard the Cloughers Creek leaves as being best placed in our '*L. stormbergensis*' and '*L. africana*' complexes.

In the Nymboida collections, *Lepidopteris* leaves are preserved on c. 3% of the catalogued slabs. While individual leaves may be identified on gross morphology with the types of *L. madagascariensis*, *L. africana* or *L. stormbergensis*, there are numerous intergrading forms that link these three 'species'. The same problem was noted by Holmes (1982) for the Benlong Flora where leaves of *L. stormbergensis*, *L. africana* and *L. mertonii* formed an intergrading series. Anderson and Anderson (1989) noted that at 11 of their 30 localities where both *L. africana* and *L. stormbergensis* were present, in most cases they formed an unbroken morphological range and were regarded as one palaeodeme. At the remaining 19 localities only one or other of the species was present.

As our collections of *Lepidopteris* have been made from the various sedimentary facies in the two Nymboida quarries they were probably sourced from differing vegetation types (Retallack 1977; Holmes 2000) and the *Lepidopteris* material may indeed belong to several true species each specific to one palaeodeme. However, on our present state of knowledge we must accept the collection as representing a single variable population sample. To enable the Basin Creek material to be compared with that from other localities, we place the *Lepidopteris* leaves in three 'species complexes' while noting the intergrading forms that link the complexes. A distinct leaf-type with widely-spaced pinnules and no intergrading links with the three 'complexes' is erected as a new morpho-species. A notable feature of *Lepidopteris* leaves, with and without preserved cuticle, is the usual presence of 'blisters' or 'lumps' on the main and/or pinna rachis (Townrow 1956, 1960, 1966; Holmes 1982; Anderson and Anderson 1989, 2003) resulting from a proliferation of epidermal cells around trichome bases. Townrow (1960) noted that in a population of leaves attributed to *Lepidopteris stormbergensis* there was a series of leaves with rachises ranging from smooth to markedly blistered. Lumps or blisters are not apparent on the Nymboida *Lepidopteris* leaves but some do have punctate or striate rachises. Townrow (1966) described the main rachis of *Lepidopteris* as having a wing and with dorsally-attached pinnae. A rachis wing is not evident in the Nymboida material and the pinnae appear to be attached laterally.

'*Lepidopteris madagascariensis* complex', based on
L. madagascariensis Carpentier 1935
Figures 1A,B; 2A–C

Selected references

- 1935 *Lepidopteris madagascariensis*, Carpentier, Pl.3, figs 3,4
1936 *Lepidopteris madagascariensis*, Carpentier, Pl.5, fig.4
1966 *Lepidopteris madagascariensis*, Townrow, Text fig. 1E, Pl.1, fig.1
1975 *Lepidopteris madagascariensis*, Flint and Gould, Pl.2, figs 1, 2
1979 *Lepidopteris madagascariensis*, Holmes and Ash, Fig.5.6, 5.7
1983 *Lepidopteris madagascariensis*, Retallack, Fig.5A
1995 *Lepidopteris madagascariensis*, Retallack, Figs 2A, 3A

Description

Small broad-elliptic bipinnate leaves c. 50–150 mm long, c. 40–70 mm wide, leaf base truncate, main rachis 2 mm wide and tapering to apex, sometimes punctate and/or longitudinally-striate; c. 20 pairs of well-separated opposite to alternate straight or arching pinnae, decreasing in length basally and apically, are attached at a high angle towards base, at c. 60° in mid-frond and more acute apically; pinnules not conjoined, oblong, truncate to obtusely rounded, attached by whole base to pinna rachis at c. 60°; first basisopic pinnule decurrent; with one or more pinnules attached laterally on rachis between pinnae. These latter are generally referred to as 'zwischenfiedern'.

Material

AMF126801–3, AMF126805 Coal Mine Quarry; AMF126804 Reserve Quarry

Discussion.

Typical leaves of this complex are not as numerous as those in the '*L. africana* complex'. It is distinguished from the two complexes below by the oblong pinnules with obtuse apices separated to the base on the mid-frond pinnae and by the higher angle of attachment of these pinnules. However, basal and apical pinnae often have coalescing to coherent pinnules. Figure 2A shows, on the same slab, portions of several leaves that obviously represent a single population (palaeodeme). One leaf is typically '*madagascariensis*' while others show pinnules becoming coherent and grading into the form of the '*L. africana* complex'.

'*Lepidopteris africana* complex', based on *L. africana* (Du Toit 1927) Holmes 1982
Figures 2D; 3A,B; 4A,B; 5A,B

Selected references.

- 1927 *Callipteridium africana*, Du Toit, Pl.27
1944 *Callipteridium argentinum*, Frenguelli, Pl.1, figs 1,2
1965 *Lepidopteris stormbergensis*, Hill et al., Pl.T6, fig.1
1977 *Lepidopteris madagascariensis*, Retallack et al., fig.9D
1982 *Lepidopteris africana*, Holmes, Figs 8C, 8D
1983 *Lepidopteris africana*, Anderson and Anderson, Pl.13, fig.1
1989 *Lepidopteris africana*, Anderson and Anderson, p.92, figs 1–3, Pl.13, figs 1–10, Pl.43, figs 1–16

- 1998 *Lepidopteris madagascariensis*, Gnaedinger and Herbst, figs 14a–c
 2001 *Lepidopteris madagascariensis*, Gnaedinger and Herbst, fig. 11a
 2003 *Lepidopteris africana*, Anderson and Anderson, p.157, fig.1

Description

Small to medium-sized bipinnatifid leaves 120–>170 mm long, 25–70 mm wide, with a truncate leaf-base 4 mm wide, tapering gradually to apex; pinnae closely spaced, longest at 2/3 of leaf length where attached at c. 45° to main rachis, apically the pinnae decrease in length and become more acute, basally the pinnae have a higher angle of attachment, become shorter, with rounded apices and entire to undulate margins; pinnae with coherent pinnules forming a serrate margin; the basiscopic base of the pinnae strongly decurrent along the main rachis to the acroscopic base of the pinna below, leaving no space for *zwischenfiedern*.

Material

AMF126806 Reserve Quarry; AMF126807–12 Coal Mine Quarry

Discussion

The leaves illustrated in Figures 3A,B and 4A were exposed on one bedding plane and surely represent a single population (*palaeodeme*). Figure 4B shows another bedding plane assemblage showing many '*L. africana*' leaves of varying size together with a fragment of a leaf with larger separated pinnules that approaches '*L. stormbergensis*' but with pinnules coalescing distally and apically. Large leaves with pinnules becoming less coherent form intergrading links between '*L. africana* complex' and '*L. stormbergensis* complex' (Figs 5C; 6A,B; 7A).

'*Lepidopteris stormbergensis* complex', based on *L. stormbergensis* (Seward 1903) Townrow 1956 Figures 6C; 8A,B; 9A,B

Selected references.

- 1903 *Callipteridium stormbergense*, Seward, Pl.7, fig.5
 1927 *Lepidopteris stuttgartensis*, Du Toit, Pl.28
 1956 *Lepidopteris stormbergensis*, Townrow, figs 1A, 1B
 1960 *Lepidopteris stormbergensis*, Townrow, text figs 5C,F,G
 1965 *Lepidopteris stormbergensis*, Hill et al., Pl.T6, fig.2

- 1975 *Lepidopteris stormbergensis*, Flint and Gould, Pl.2, figs 1,2
 1977 *Lepidopteris madagascariensis*, Retallack et al. fig. 9A
 1982 *Lepidopteris stormbergensis*, Holmes, fig.8A
 1983 *Lepidopteris stormbergensis*, Anderson and Anderson, Pl.13, figs 2,3
 1989 *Lepidopteris stormbergensis*, Anderson and Anderson, p.93, figs 1–4, Pl.26, figs 2–5, Pl. 27, figs 1–4
 1998 *Lepidopteris madagascariensis*, Gnaedinger and Herbst, Pl.3, fig.h, figs 14a,c
 2003 *Lepidopteris stormbergensis*, Anderson and Anderson, p.157, fig.4

Description.

Large bipinnate to tripinnatifid leaves, broad-oblongate, to 400 mm long and 180 mm wide. Rachis to 5 mm in mid-frond; pinnae opposite to alternate, longer pinnae at mid-frond attached at c. 80°–45°, closely spaced to overlapping on larger and tripinnatifid fronds; pinnules on mid-portion of mid-pinnae 6–25 mm long, 3–6 mm wide, tapering to acute or narrow obtuse apex, margin entire to serrate. On the largest leaves (Figures 8B, 9B) the pinnules are deeply lobed to pinnatisect. First basiscopic pinnule attached to base of pinna rachis or strongly decurrent on main rachis; nil to three *zwischenfiedern* between pinnae on main rachis in mid-portion of leaf.

Material

AMF126816–21, AMF126851, all Coal Mine Quarry.

Discussion

The leaf assemblage preserved on AMF126819, AMF126821 and AMF126851 are parts and counterparts from the same bedding plane and show fronds ranging from bipinnatifid to tripinnatifid and include the largest in the collection (Figure 8B). *Zwischenfiedern* preserved on the tripinnatifid leaf (Figure 9B) are broad-elongate with a lobed margin. This assemblage demonstrates the large range of variation even within a single population.

Lepidopteris dissitipinnula Holmes and Anderson
 sp. nov.
 Figures 10A–C

Diagnosis

A medium-sized *Lepidopteris* leaf with sub-opposite slightly arching to recurved pinnae; pinnules well-spaced, elongated-linear with obtuse

apices, margins parallel, entire to lobate.

Description

Based on two specimens, both with base and apices missing, length preserved to 110 mm; rachis at base of preserved section 2–3 mm wide; pinnae elongate-lanceolate, alternate, c. 12 mm apart, longest pinnae to 65 mm. Specimen AMF113528 (Figures 10A,B) has slightly recurved pinnae attached at c. 60°; AMF126823 (Figure 10C) has lower pinnae attached at right angles and arching slightly and the upper pinnae attached at c. 60°, but this may also be an artifact of preservation. Pinnules opposite, spaced c. one pinnule width apart, decurrent, straight or slightly arched, apex rounded-obtuse, margins parallel, entire to lobate. Pinnules are longest at mid-pinna, to 12 mm long, 1–2 mm wide, decreasing in length basally and apically, basal basisopic pinnule not decurrent on main rachis; one or two pairs of narrow, elongate *zwischenfiedern* on main rachis between pinnae.

Holotype

AMF113528 and counterpart AMF113529
Australian Museum, Sydney.

Type Locality

Coal Mine Quarry. Basin Creek Formation,
Nymboida Coal Measures, Middle Triassic.

Other material

AMF126823 Coal Mine Quarry.

Name Derivation

dissitus, (Lat.) *well-spaced*; referring to the well-separated pinnules.

Discussion

Lepidopteris dissitipinnula differs from all described *Lepidopteris* morpho-species by the elongated-linear well-spaced pinnules and perhaps is closest to *L. madagascariensis*. However, at Nymboida there are no intergrading forms to link *L. dissitipinnula* with the '*L. madagascariensis* complex'. Both specimens of *L. dissitipinnula* are preserved in a white sandstone matrix in contrast to all other *Lepidopteris*, material which is preserved in black to grey shales and mudstones, thus suggesting they were sourced from ecologically separated populations.

Genus *Peltaspermum* Harris 1937
Type species. *Peltaspermum rotula* Harris
1937

The ovulate organ *Peltaspermum* had a wide Laurasian and Gondwanan distribution. It is generally accepted as the female fructification of the plant that bore *Lepidopteris* leaves (Thomas 1933; Harris 1937, Townrow 1960, Anderson and Anderson 2003). Poort and Kerp (1990) revised the *Peltaspermum* - *Lepidopteris* association based on western and central European material. They proposed the creation of the 'natural genus' *Peltaspermum* by emending the diagnosis of *Peltaspermum* to include *Lepidopteris* leaves. As *Peltaspermum* and *Lepidopteris* are both morpho-taxa under ICBN (2001) Article 1.2 a new name would be required for a 'natural genus'.

Despite the large number of *Lepidopteris* leaves in the Nymboida collection, *Peltaspermum* is known only from two incomplete strobili and two detached peltate discs.

Peltaspermum cf monodiscum Anderson and
Anderson 2003
Figures 11A–E

Description

Based on two incomplete strobili. Axes as preserved c. 40 mm and 25 mm long, 2 mm wide; six discs c. 4 mm in diameter attached at 8–10 mm intervals singly or opposite each other by a peduncle c. 5 mm long. Each disc is c. 6 mm wide, pendant, showing four decurved, linear lobes 4 mm long, 1 mm wide. As the fossils represent sideways-compressed discs, the number of lobes in life would be eight. A single detached disc and its counterpart (Figures 11D, E) show a radially symmetrical disc c. 9 mm in diameter with ten linear lobes around the circumference, each c. 1 mm wide and 2–3 mm long. A possible peduncle protrudes from one side of the disc but its point of attachment is uncertain.

Material

AMF126824–6 Coal Mine Quarry.

Discussion

Anderson and Anderson (2003 pp. 152, 158, 159) described and illustrated from the Molteno Formation of South Africa some reasonably intact strobili with lobed receptacles attached singly to an axis. They refer to the receptacles as 'discs'. Their specimens have 11 or 12 lobes. The Nymboida material with 8–10 lobes is otherwise closely comparable.

***Peltaspermum* sp A**
Figures 11F,G

Description

One specimen and its counterpart shows a spherical disc 18 mm in diameter with c. 13–14 broad obtuse lobes around the margin, each separated by an incision or ridge reaching from half to two thirds distance to the centre, which is marked with an irregular-shaped abscission scar c.1.8 mm in diameter.

Material

AMF126852 and counterpart AMF126853 Coal Mine Quarry.

Discussion

Peltaspermum sp. A differs from *P. cf. monodiscum* by the larger size and less incised lobes. Similar detached peltoid discs have a wide distribution and are associated in Gondwana deposits with the peltaspermaceous genera *Lepidopteris* (Harris 1937; Holmes and Ash 1979; Holmes 1982, Anderson and Anderson 2003) and *Scytophyllum* (Zamuner et al. 1999) and in the Northern Hemisphere with *Lepidopteris*, *Tatarina*, *Comia*, *Pachydermophyllum* and *Scytophyllum* (Meyen 1987). This isolated Nymboida disc has insufficient diagnostic features to place it in any known species.

Genus *Antevsia* Harris 1937

Type species *Antevsia zeilleri* (Nathorst) Harris 1937

Antevsia strobili have been recorded from Rhaetic localities in Sweden (Antevs 1914), Greenland (Harris 1932) and from the Upper Triassic Molteno Formation of South Africa (Anderson and Anderson 2003). *Antevsia* has been linked at those occurrences with *Lepidopteris* on the basis of similar cuticles (Antevs 1914; Harris 1932) and the same distinctive blistering on the strobilis axes as on the foliar rachises (Anderson and Anderson 2003).

Antevsia sp A

Figures 12A–C

Description

Two fragmentary specimens from Nymboida show clusters of sessile sporangia. AMF 126828 (Figures 12A,B) is a portion of a strobilis overlain by a fragment of a *Sphenobaiera* leaf. The curved axis, which may be an almost complete branch, is c. 60 mm long, 1.4 mm wide at the base and tapering to 0.8 mm distally. Blisters are not apparent. Clusters of up to five irregularly elliptic microsporangia to 2 mm long are scattered along the branch axis. It is not certain

whether the sporangial sacs are sessile or shortly pedunculate. The second specimen, AMF126829 (Figure 12C), is of two detached clusters and some scattered sporangial sacs to 5 mm long. Associated with the sporangia is a detached oval-shaped indeterminate ovule.

Material

AMF126828 and AMF126829 Coal Mine Quarry.

Discussion

Antevsia sp. A has some similarities to *Antevsia mazenodensis* Anderson and Anderson (2003) from the Molteno Formation but the preservation is not sufficient for specific determination.

Order Matatiellales Anderson and Anderson 2003

Family Matatiellaceae

Genus *Kurtziana* Frenguelli 1942a

Type species *Kurtziana cacheutensis* (Kurtz) Frenguelli 1942a

In frond morphology and venation pattern *Kurtziana* differs from all other Gondwanan ginkgoopsid leaf genera. Based on mutual occurrence Anderson and Anderson (2003) have given a Grade 2 affiliation of *Kurtziana* leaves with the female strobilis *Matatiella* and placed the leaf genus in the Order Matatiellales.

The genus *Kurtziana* was erected by Frenguelli (1942a) for unforked pinnate leaves with pinnae having contracted pinna bases and attached laterally to the rachis. These leaves from Argentina were first illustrated by Kurtz (1921, Pl. 16, figs 198–199) as *Danea cacheutensis*. A second species, *K. brandmayri* Frenguelli (1944), was erected for leaves in which the pinnae were closely-spaced to imbricate and attached to the dorsal surface of the rachis. A very large leaf from Chile has recently been described as *K. paipotensis* Herbst and Gnaedinger (2002). *Kurtziana* leaves with preserved cuticle have been described by Petriella and Arondo (1982) and Artabe et al. (1991). Herbst and Gnaedinger (2002) have erected the new morpho-genus *Alicurana* for *Kurtziana* leaves with preserved cuticle. To date *Kurtziana* is best known from South American localities.

Kurtziana leaves are also known from South Africa (Du Toit 1927; Anderson and Anderson 1983). In a recent publication, Anderson and Anderson (2003) illustrated five species and noted the presence of 16 species, generally of rare occurrence, from the Molteno Formation of South Africa. From Australia, the leaf '*Thimfeldia*' *eskensis* Walkom (1928) is here

transferred to *Kurtziana cacheutensis*.

Kurtziana leaves are represented on c. 2% of catalogued slabs in the Nymboida collection. They are preserved as impressions and due to their probable coriaceous nature, only rare examples show clear details of the venation. One bedding plane in Coal Mine Quarry was covered with complete *Kurtziana* leaves, perhaps indicating an autumnal deposit of a deciduous plant. The Nymboida specimens exhibit a range of variation in frond and pinna size, in pinna shape and manner of attachment to the rachis. Some agree closely with the types of *K. cacheutensis* and *K. brandmayri*, others with *K. cacheutensis* sensu Herbst and Gnaedinger (2002) from collections that also exhibited a variation in leaf form. We have separated the leaves into two 'species complexes' based essentially on the perceived dorsal or lateral attachment of the pinnae to the rachis, a feature sometimes obscured by the manner of preservation.

'*Kurtziana brandmayri* complex', based on
Kurtziana brandmayri Frenguelli 1944
Figures 13A,B

Selected references.

- 1944 *Kurtziana brandmayri*, Frenguelli, text fig. 2, Pl. 4, figs 1,2
1965 "*Thinnfeldia*" *eskensis*, Hill et al., Pl. T5, figs 3,4
1991 *Kurtziana brandmayri*, Artabe et al., Fig. 1
2002 *Kurtziana brandmayri*, Herbst and Gnaedinger, figs 2A–C; Pl. 4, figs D–F

Description.

Kurtziana leaves with elliptic lamina, to c. 240 mm long, 100 mm wide, rachis to 4 mm wide, decreasing in width distally, striate and sometimes punctate, with expanded leaf base. Pinnae opposite to sub-opposite, closely spaced to overlapping, sessile, with contracted auriculate or caudate bases, attached to the dorsal surface of the rachis; oblong to linear-ovate or tapering to rounded-acute apex, 40–50 mm long, 8–18 mm wide; basal pinnae broad-oval, increasing in length to mid-portion of leaf. Angle of attachment of pinnae to rachis, from 80° near base to 75° in mid-leaf and becoming more acute apically.

Material

AMF126830–1 Coal Mine Quarry.

Discussion

The Nymboida specimen on Figure 13A agrees closely with the type of *K. brandmayri* (Frenguelli 1944, Pl. 4, figs 1,2) by the closely-spaced to

overlapping oblong pinnae with obtuse apices and constricted auriculate bases attached at a high angle to the rachis. Other specimens with a dorsal attachment of the pinnae and contracted bases differ by the pinnae being not so closely-spaced, with a more acute angle of attachment and by the tapering of the pinnae to a narrower rounded-acute apex.

'*Kurtziana cacheutensis* complex', based on
Kurtziana cacheutensis (Kurtz) Frenguelli 1942a

Figures 14A–D; 15A; 16A,B; 17A

Selected references

- 1928 '*Thinnfeldia*' *eskensis*, Walkom, Pl.27, fig. 2, Pl.28, fig. 1
1942a *Kurtziana cacheutensis* (Kurtz) Frenguelli, Pl.1
1975 *Dicroidium eskense*, Flint and Gould, Pl. 3, fig. 3
1983 *Kurtziana cacheutensis*, Anderson and Anderson, Pl. 9, fig. 5
2002 *Kurtziana cacheutensis*, Herbst and Gnaedinger, Fig.1A–H

Description

Elliptic-ovate pinnate leaves, 100–200 mm long, 40–100 mm wide, pinnae attached laterally to a striated rachis 2–3 mm wide, opposite to alternate, separated by c. one pinna width, linear-oblong, tapering slightly to acute rounded apex, to 45 mm long, 9 mm wide in midleaf, pinna acroscopic base contracting to midvein, basiscopic base contracted or variously decurrent. Pinnae inserted laterally on rachis at c. 60° becoming more acute apically.

Material

AMF126832–9 Coal Mine Quarry.

Discussion

This is the most common form of *Kurtziana* at Nymboida, sometimes forming monotypic autumnal deposits on a bedding plane (Figure 15A) or associated with leaves of the conifer *Rissikia* (Figure 16B). This species complex is separated from the *K. brandmayri* complex by the lateral attachment of the pinnae to the rachis. Some specimens (Figures 15A and 16A) are closely comparable with the illustrated type of *K. cacheutensis* (Frenguelli 1942a). However, there is a wide range of variation in leaf size, pinna size and shape, spacing and inclination of pinnae to rachis and the degree of contraction or decurrence of the basiscopic base of the pinna. Figure 17A shows two leaves with extreme decurrent pinnae in the apical

half of the leaf and contacted pinnae in the basal half. Some leaves (e.g. Figure 14C) appear to have pinnae with asymmetrical laminae but this is probably an artifact of preservation caused by the inrolling of one edge of the pinna.

Order Petriellales Taylor et al. 1994

Family Kannaskoppiaceae Anderson and Anderson 2003

Genus *Rochipteris* Herbst, Troncoso and Gnaedinger 2001

Type species *Rochipteris lacerata* (Arber) Herbst et al. 2001

Flabellate leaves with anastomosing venation have long been known from the Triassic floras of Gondwana. Early records were from Queensland by Carruthers (1872, as *Cyclopteris cuneata*) and Shirley (1898, as *Sagenopteris cuneata*), from Tasmania by Johnston (1888 as *Cyclopteris australis*), from Victoria by Chapman (1927 as *Psygmophyllum fergusonii*), from New Zealand by Arber (1917 as *Chiropteris lacerata*), from Chile by Solms-Laubach (1899 as *Chiropteris copiapensis*) and South Africa by Seward (1903 as *Chiropteris cuneata*). Other records may be found in Etheridge (1895), Chapman and Cookson (1926), Frenguelli (1942b, 1944) and Menendez (1951). The taxonomy of the group was confused. Retallack (1980) discussed the problems and subsequently recognised six species under an emended diagnosis for *Ginkgophytopsis*. Herbst et al. (2001) made a detailed analysis of the significant differences between the essentially Northern Hemisphere genus *Ginkgophytopsis* and the Gondwanan leaves. For the Gondwanan leaves they erected the new genus *Rochipteris* in which was included five species based mainly on material from Argentina and Chile. Barone-Nugent et al. (2003) redescribed leaves from the Leigh Creek Coal Measures of South Australia and the Ipswich Coal Measures of Queensland as *Rochipteris etheridgei* and *R. ginkgoides* respectively.

In a recent significant publication on Gondwana Triassic gymnosperms, Anderson and Anderson (2003) described some remarkable material from the Molteno Formation of South Africa. Included were specimens of flabellate leaves with anastomosing venation and with either female or male fructifications attached to a stem. The female strobili were described as *Kannaskoppia*, the male strobili as *Kannaskoppianthus* and the attached leaves as *Kannaskoppifolia*. Under ICBN (2001), Article 1.2, detached leaves are regarded as morpho-taxa and

thus *Rochipteris* Herbst et al. (2001) has priority over *Kannaskoppifolia*. *Kannaskoppifolia* may be used as a genus for leaves attached to a stem.

Anderson and Anderson (2003) regarded *Kannaskoppiafolia* (= *Rochipteris*) as “ubiquitous, diverse, long-lived, relatively frequent but generally lacking in abundance”. Barone-Nugent et al. (2003) noted that their *Rochipteris* species appeared to be distinct between separate basins and showed a strong degree of intra-Gondwanic provincialism in marked contrast to *Dicroidium* species, which are widely distributed throughout Gondwana (Retallack 1977; Anderson and Anderson, 1983; Holmes and Anderson, in press). Forty years of collecting at Nymboida has yielded the six new species described below, but, with the exception of two species, the others are represented by a single specimen only. The species have been distinguished on leaf morphology, venation pattern and vein density. Two of the Nymboida species are important in demonstrating, for some species at least, that *Rochipteris* foliage is inserted on the stem either as a close spiral or a terminal whorl.

Rochipteris obtriangulata Holmes and Anderson sp. nov.

Figures 18A–C; 19A–D

Diagnosis

Obtriangular lamina, lateral and distal margins straight, entire; angle of divergence 20°–30°; veins sub-parallel, dichotomising c. five times and anastomosing twice in distal half of lamina; leaves attached in close spirals or whorls of eight to ten; venation density 20–25 per 10 mm.

Description

Based on a slab bearing impressions of one almost complete whorl and two incomplete whorls plus other isolated single leaves. The leaves are obtriangular, c. 40 mm long and 12 mm wide at the truncate apex. Lamina diverging from the acute sessile base at c. 20°–30°. Lateral margins straight, leaf apex truncate, straight and entire. Veins sub-parallel, dichotomising close to base and then four or five more times to leaf apex; from c. mid-lamina the veins converge and conjoin with adjacent veins, usually twice, to form irregular linear elliptical areoles; venation density at 2/3 leaf length 20–25 per 10 mm. Foliage arranged in a close spiral or a terminal whorl of 8–10 leaves but leaf bases and stem not visible.

Holotype

AMF126840 and counterpart AMF126842;

paratype AMF126841, Australian Museum, Sydney.

Type Locality

Coal Mine Quarry, Nymboida. Basin Creek Formation, Nymboida Coal Measures, Middle Triassic.

Name Derivation

obtriangulata (Lat.), *obtriangular*; referring to the reversed triangular leaf form.

Discussion

The straight lateral margins of the expanding laminae and the truncate entire apex differentiates *R. obtriangulata* from all other described *Rochipteris* species. They are close to the leaves from the Molteno Formation locality Umk111 illustrated as *Kannaskoppifolia* sp. C by Anderson and Anderson (2003).

Rochipteris tubata Holmes and Anderson sp. nov.
Figures 20A–C

Diagnosis

Vase-shaped lamina, lateral margins concave, distal margin convex-rounded, entire; angle of divergence at base 15° increasing to 60°–90° apically; veins sub-parallel, dichotomising from near base, anastomosing in distal 2/3 of lamina. Foliage in a close spiral or whorl of c. 7 leaves; vein density 20–25 per 10 mm.

Description

Based on one almost complete whorl of seven leaves. Lamina vase-shaped; leaves to 30 mm long, 19 mm wide, rising from an attenuated base at c. 15° and expanding distally in a curve to 60°–90°. Lateral margins concave, apical margin convex-rounded, slightly undulate. Venation sub-parallel, dichotomising c. five times from near base and anastomosing in distal 1/3 of lamina. Seven leaves apparently attached in a close spiral or terminal whorl but leaf bases and stem not visible. Density of veins c. 20–25 per 10 mm.

Holotype

AMF126843 Australian Museum, Sydney.

Type Locality

Coal Mine Quarry, Nymboida. Basin Creek Formation, Nymboida Coal Measures, Middle Triassic.

Name Derivation

tubata (Lat.), *trumpet*; referring to the expanding outline of the leaf lamina.

Discussion

Rochipteris tubata is arranged in a whorl of leaves similar to *R. obtriangularis* but unfortunately in neither species is their attachment to the stem visible. The venation in both species is similar but *R. tubata* is separated on the basis of the expanding lamina and rounded leaf apex. The whorls of leaves in *R. obtriangulata* and *R. tubata* suggest a strong relationship to the stems bearing *Kannaskoppia* fruits (Anderson and Anderson 2003), which have small groups or whorls of leaves attached at intervals along the slender stem.

Rochipteris incisa Holmes and Anderson sp. nov.
Figures 21A–C; 22A

Diagnosis

Medium-sized cuneate leaf with arched apex; one to six deep incisions to below mid-lamina forming sub-parallel lobes; venation parallel, occasionally bifurcating or conjoining to form extremely elongated linear areoles. Venation density c. 18 per 10 mm.

Description

Based on three leaves from the Reserve Quarry and eight from Coal Mine Quarry. Leaf cuneate, to 115 mm long and c. 70 mm wide; lateral margins straight or slightly concave, diverging from base at c. 45°–80°; apex semicircular, deeply incised to form a number of linear segments from 8–10 mm wide, incisions reaching to 1/3 distance from the lamina base, distal ends of segments entire or with a minor incision. Veins fine and parallel, dichotomising and occasionally conjoining to form extremely elongated areoles; density of veins c. 18 per 10 mm.

Holotype

AMF126844 Australian Museum, Sydney.

Type Locality

Reserve Quarry, Nymboida. Basin Creek Formation, Nymboida Coal Measures.

Other Material

AMF126827, 126862, Reserve Quarry;
AMF126863–66, Coal Mine Quarry.

Name Derivation

incisa, (Lat.), *incised*, referring to the regularly

incised distal margin.

Discussion

Rochipteris incisa shows some similarities in shape and outline to the attached Molteno leaves *Kannaskoppifolia vincularis* (Anderson and Anderson 2003). It differs from all other Nymboida *Rochipteris* spp in lamina shape and venation details. *Rochipteris etheridgei* (Arber) Barone-Nugent et al. is similar in outline to *R. incisa* but differs by its larger size, the less-deeply incised segments, the sinuate venation and by the presence of a broadly-flared leaf base (Barone-Nugent et al. 2003, fig. 3B, Pl. 1, figs 2–5).

On the same slab and adjacent to the holotype of *R. incisa* is a smaller spatulate leaf with venation similar to that of *R. incisa* (Figure 21B). This spatulate form is similar to leaves from Argentina that have been placed in *Rochipteris cuneata* (Carruthers) Herbst et al. 2001. That species was based on *Cyclopteris cuneata* Carruthers (1872), a poorly preserved leaf fragment with both apex and base missing. We believe that our spatulate leaf may belong to the same population as *R. incisa* and perhaps represents a juvenile or immature stage of development.

***Rochipteris sinuosa* Holmes and Anderson sp. nov.**
Figures 23A–C

Diagnosis

A small flabellate leaf, diverging at c. 45° from short expanded leaf base; divided into two major segments by a deep incision; one segment again divided by a shallower incision; veins radiating from base, sinuous, approaching and diverging from each other, occasionally dichotomising but rarely anastomosing. Vein density c. 18 per 10 mm.

Description

Based on a single leaf with apical margin missing. Leaf as preserved, 42 mm long, 25 mm wide; flabellate, expanding at c. 45° from a short flared leaf base 4 mm wide. Lamina divided into two major segments by a medial incision commencing at c. 12 mm from the leaf base; the left segment is again divided by a narrow incision commencing at 18 mm from the base. The lamina lateral margins are slightly concave, the apical margin is missing. Veins run in a sub-sinuous manner parallel to the lateral margins, dichotomising occasionally, approaching and diverging from each other but rarely forming a true anastomosis. The apparent areoles are elongate-elliptic. Vein density in the upper portion of the lamina c. 18 per 10 mm.

Holotype

AMF126845 Australian Museum, Sydney.

Type Locality

Coal Mine Quarry, Nymboida. Basin Creek Formation, Nymboida Coal Measures, Middle Triassic.

Name Derivation

sinuosa (Lat.) *sinuous*; referring to the venation.

Discussion

The gross morphology, sub-sinuous venation and paucity of anastomoses distinguishes this leaf from other Nymboida *Rochipteris* species. *Rochipteris sinuosa* closely resembles the specimens from the Llantenes Formation of Argentina attributed to *Chiropteris copiapiensis* Steinmann and Solms by Menendez (1951, Pl.3, figs 1–4). However, those specimens have been synonymised with *Rochipteris lacerata* (Arber) as a new combination by Herbst et al. (2001). *Rochipteris lacerata* was described originally from New Zealand by Arber (1917) as *Chiropteris lacerata* and after detailed discussion by Retallack (1980, 1983) was transferred to the genus *Ginkgophytopsis*. *Rochipteris lacerata* sensu Herbst et al. (2001) is larger than *R. sinuosa*, is deeply incised into several parallel-sided segments and has straight parallel venation that dichotomises and anastomoses to form long areoles. *Rochipteris copiapiensis* (Solms-Laubach) sensu Herbst et al. (2001) is a large leaf divided into two equal segments with straight, bifurcating and anastomosing venation. In outline and venation pattern, *R. sinuosa* differs from the ten illustrated but undescribed *Kannaskoppifolia* = *Rochipteris* leaves from the Molteno Formation (Anderson and Anderson 2003).

***Rochipteris nymboidensis* Holmes and Anderson sp. nov.**

Figures 24A–D

Diagnosis

A small cuneate leaf, lateral margins concave, apical margin convex, entire; venation dense, straight and parallel, dichotomising, very rarely anastomosing; vein density c. 30–35 per 10 mm.

Description

Based on a single specimen. A cuneate leaf 63 mm long, with leaf base missing, 50 mm wide at the entire to slightly undulate apex. Angle of divergence from base c. 25°, increasing to 90° at lamina apex. Venation very fine, parallel, straight, dichotomising

and very rarely anastomosing. Density of veins across mid-upper portion of lamina c. 30–35 per 10 mm.

Holotype

AMF126846 Australian Museum, Sydney.

Type Locality

Coal Mine Quarry, Nymboida. Basin Creek Formation, Nymboida Coal Measures.

Name Derivation

nymboidensis, referring to the Type Locality.

Discussion

The entire leaf with very dense venation with only rare cross connections distinguishes this leaf from all other described species of *Rochipteris*. *Rochipteris nymboidensis* is similar in outline but differs by the denser venation and fewer anastomoses from the undescribed *Kannaskoppifolia* sp. D of Anderson and Anderson (2003).

Rochipteris pusilla Holmes and Anderson sp. nov.

Figures 25A–C

Diagnosis

A very small cuneate leaf, lateral margins slightly convex, apex entire to undulate; venation dichotomising to five times from base, becoming more dense apically, conjoining to form linear areoles in apical half of lamina; in upper 2/3 of lamina venation density c. 21 per 10 mm.

Description

Based on a single almost complete leaf and its counterpart. Lamina narrow cuneate, 20 mm long, 14 mm wide; leaf base truncate 1.5 mm wide, diverging at ca. 45°, lateral margins entire, slightly convex; apex entire to slightly undulate. Two veins enter the base of the lamina, each bifurcates five or six times to terminate at distal margin. In the distal 1/3 of the lamina adjacent veins sometimes conjoin to form elliptic areoles, which become shorter and narrower towards the leaf apex; vein density across the upper 2/3 of the lamina is c. 21 per 10 mm.

Holotype

AMF126854 and counterpart AMF126855; Australian Museum, Sydney.

Type Locality

Coal Mine Quarry, Nymboida. Basin Creek Formation, Nymboida Coal Measures.

Name Derivation

pusilla, (Lat.), *very small*; this being the smallest *Rochipteris* species as yet described.

Discussion

The previously-described smallest leaf, *Rochipteris tasmanica* (Walkom) comb. nov., differs from *R. pusilla* by its larger size, the lamina expanding more widely and with a sparser, more open network of veins with a density of c. 10 per 10 mm (Walkom 1925) The venation of *R. pusilla* is somewhat similar to that in the small but less diverging leaves illustrated as *Kannaskoppifolia* sp. A and *K. sp. B* by Anderson and Anderson (2003) from the Molteno Formation of South Africa.

Sedis Incertae

Genus *Walkomiopteris* Holmes and Anderson gen. nov.

Walkomiopteris eskensis (Walkom) gen. et comb. nov.

Figures 26A–F

Type species *Sphenopteris eskensis* Walkom 1928, Pl.16,3; text fig.4

Combined diagnosis

Small wedge-shaped to semi-circular leaves apparently arranged in pairs, axis unknown; proximal portion of lamina contracted to petiole-like base; primary vein thick at base, dichotomising up to three times to form sparse radiating veins to lamina apical margin.

Description

Based on the type specimen of Walkom (1928) and four additional specimens from the Nymboida quarries. The individual leaves are conjoined into pairs; 17–30 mm long, 15–20 mm wide, wedge-shaped to semicircular, margin entire or variously shallowly-lobed; contracted into a petiole-like base to 5 mm long; a stout midvein enters the base of the lamina and soon dichotomises up to three times, with the fine venules radiating distally; c. 16 vein endings around lamina apical margin. Walkom's specimen from the Esk Beds of Queensland (Figure 26A) shows a cluster of eight irregularly-arranged but not connected leaves, the best preserved leaf is c. 20 mm long, 15 mm wide with fine radiating and dichotomising veins. The Nymboida material is larger, to 30 mm x 20 mm. On two specimens

(Figures 26B,C,D) leaves are conjoined into pairs while AMF113490 (Figure 26F) suggests a whorled arrangement but no axis or stem is preserved. While cuticle is not preserved, specimen AMF113492 shows an impression of cellular structure of rounded thick-walled cells and elongated rectangular cells along the veins (Figure 27C).

Material

Type specimen F1729 Queensland Museum, Brisbane, from railway cutting near Ottaba railway station. AMF113440, Coal Mine Quarry; AMF113491–3, AMF126848–9, Reserve Quarry Nymboida.

Name derivation

Walkomiopteris – for the eminent palaeobotanist and mentor to WBKH, Dr A.B. Walkom, who described the type material from the Esk Beds of Queensland.

Discussion

Walkom (1928) noted that this was a unique form of leaf in the Australian Mesozoic. In the mistaken belief that the leaves were pinnately connected to a rachis, he placed them in the genus *Sphenopteris*, a generalised leaf form with similar venation and which ranges from Devonian to Jurassic. *Sphenopteris* probably includes both ferns and pteridosperms (Boureau 1975). Anderson and Anderson (1983 Pl.9 figs 2,3) illustrated as foliage gen. B, sp. A, paired leaves with radiating venation similar to *Walkomiopteris*, but later collected material reveals that they belonged to a pinnate fern (Anderson and Anderson in press).

CONCLUSION

Leaves of the form-genera *Lepidopteris* and *Kurtziana* are preserved on 3% and 2% respectively of catalogued slabs in the Holmes Nymboida Collection. This has provided ample material to appreciate the range of variation existing in the genera. Recognising this variation we have placed the *Lepidopteris* leaves into three ‘species complexes’, each complex includes a range of variation with intergrading forms linking the complexes. One leaf form without links to the ‘species complexes’ is described as the new species *Lepidopteris dissitipinnula*. *Kurtziana* leaves are separated into two ‘species complexes’ based on the dorsal or lateral attachment of the pinnae; each complex includes leaves of variable morphology. Leaves of *Rochipteris* are rare, but on selected diagnostic features we have erected six new morpho-species. Due to the very limited material, the variation

that may exist within a ‘species’ or the possibility of intergrading forms between ‘species’ is unknown. The leaf morphology of *Walkomiopteris eskensis* is unique among Gondwanan Triassic plants. This morpho-species probably represents the foliage of a gymnospermous plant.

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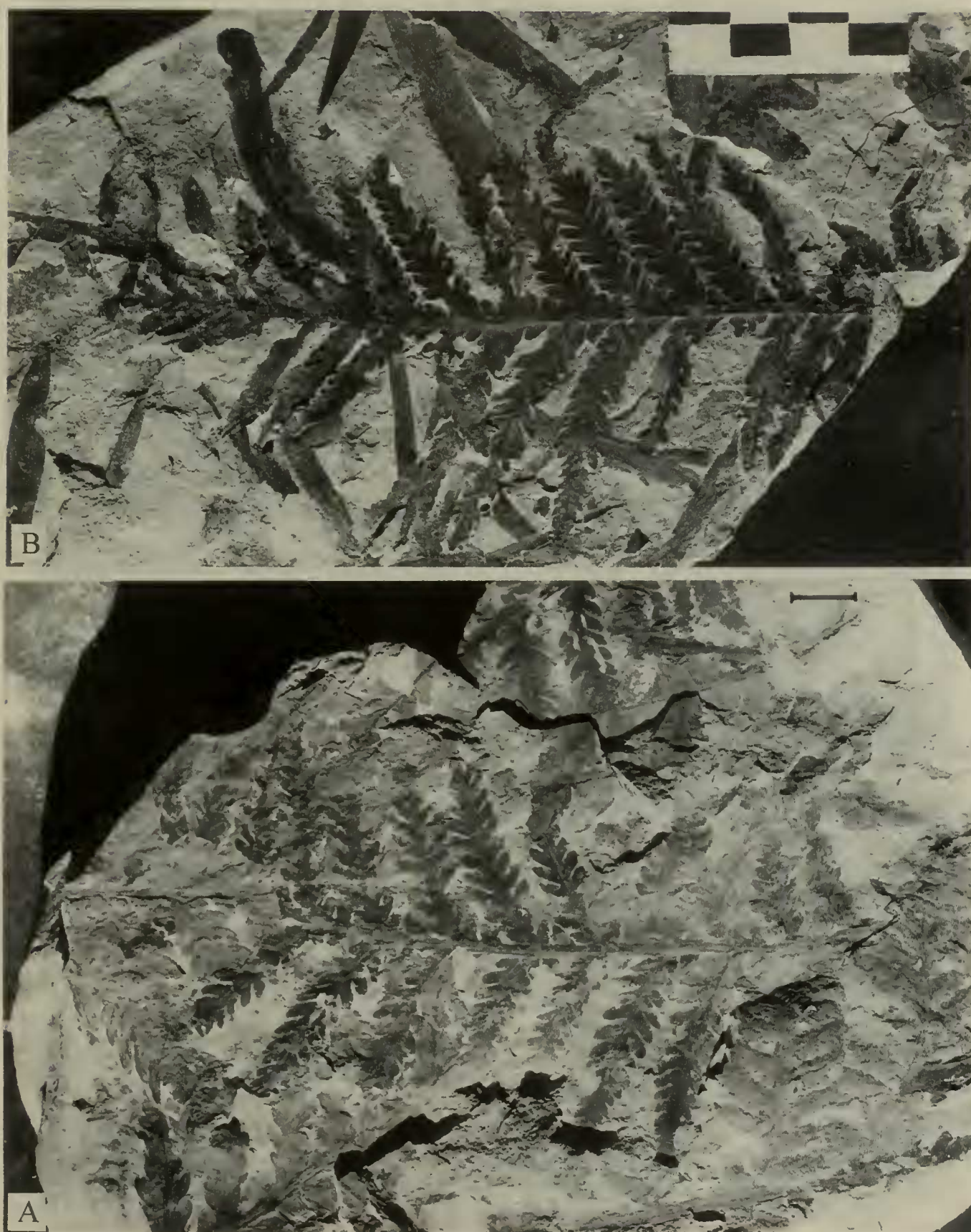


Figure 1, A,B. '*Lepidopteris madagascariensis* complex' A. AMF126801; B. AMF126802. Both Coal Mine Quarry. Scale bar = 1 cm



Figure 2. A. Centre leaf '*Lepidopteris madagascariensis* complex', other leaves intergrading with '*Lepidopteris africana* complex'. AMF126803, Coal Mine Quarry. B,C. '*Lepidopteris madagascariensis* complex'. B. AMF126804, Reserve Quarry. C. AMF126805, Coal Mine Quarry. D. Leaves grading to '*L. africana* complex'. AMF126806, Reserve Quarry. Scale bar = 1 cm.



Figure 3. A,B. '*Lepidopteris africana* complex'. A. AMF126807. B. AMF126808. Both Coal Mine Quarry. Scale bar = 1 cm.



Figure 4. A. '*Lepidopteris africana* complex'. AMF126809. B. '*L. africana* complex', leaf at top right '*L. stormbergensis* complex'. AMF12806810. Both Coal Mine Quarry. Scale bar = 1 cm.

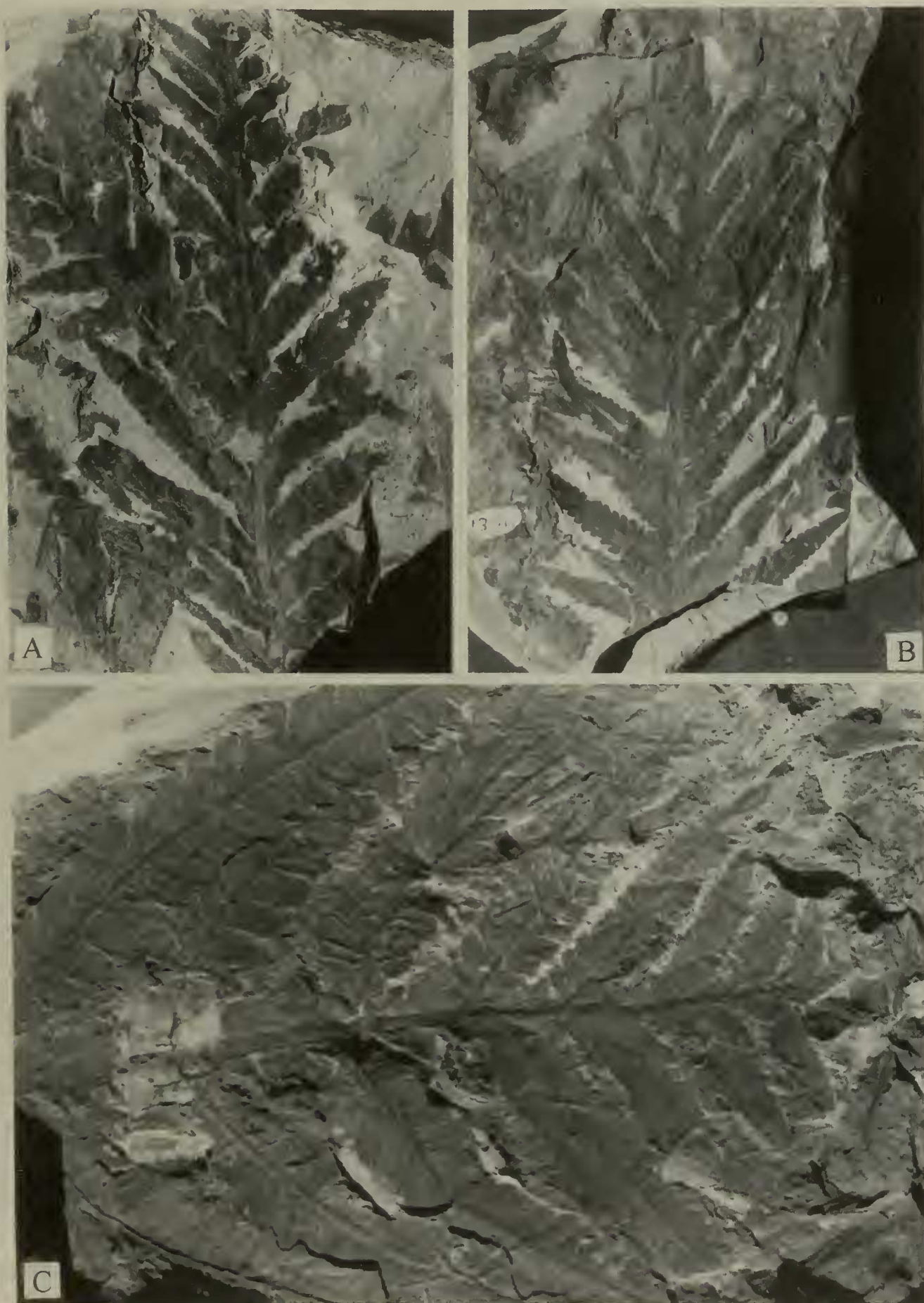


Figure 5. A,B. '*Lepidopteris africana* complex'. A. AMF126811. B. AMF126812. C. '*L. stormbergensis* complex'. AMF126813. All from Coal Mine Quarry. Scale bar = 1 cm.



Figure 6. A,B. '*Lepidopteris africana* complex' intergrading with '*L. stormbergensis* complex'. A. AMF126814, Reserve Quarry. B. AMF126815, Coal Mine Quarry. C. Small complete leaf of '*L. stormbergensis* complex'. AMF126816, Coal Mine Quarry. Scale bar = 1 cm.



Figure 7. A. Intergrading form between '*L. africana* complex' and '*L. stormbergensis* complex'. AMF126817, Coal Mine Quarry. Scale bar = 1 cm.



Figure 8. A,B. '*Lepidopteris stormbergensis* complex'. A. AMF126818. B. AMF126819. Both from Coal Mine Quarry. Scale bar = 1 cm.



Figure 9. A,B. '*Lepidopteris stormbergensis* complex'. A. AMF126820. B. AMF126851, lobed zwisherfied-ern arrowed. Both from Coal Mine Quarry. Scale bar = 1 cm.

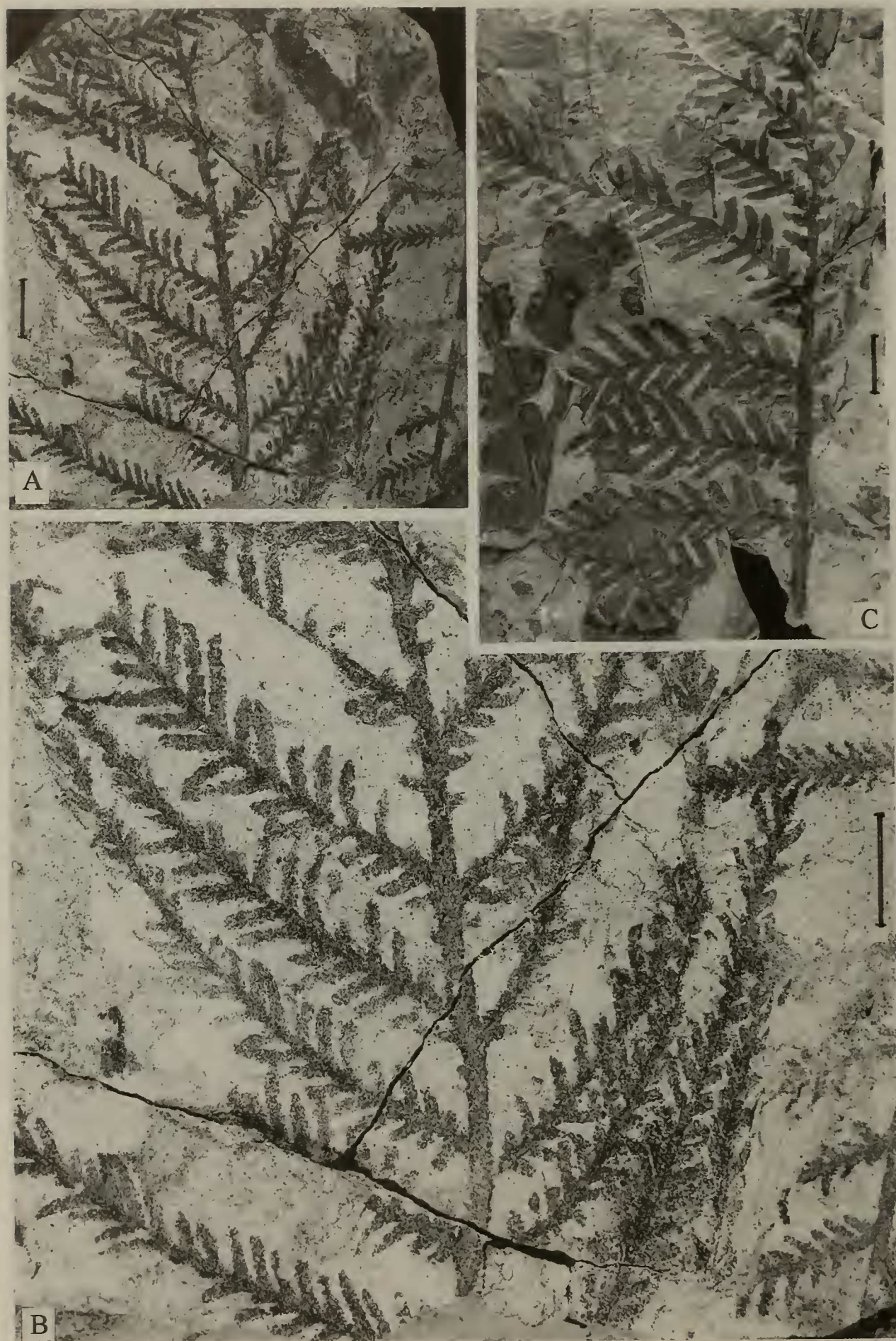


Figure 10. A-C. *Lepidopteris dissitipinnula* sp. nov. A, B. AMF113528. Holotype. C. AMF126823. Both from Coal Mine Quarry. Scale bar = 1 cm.

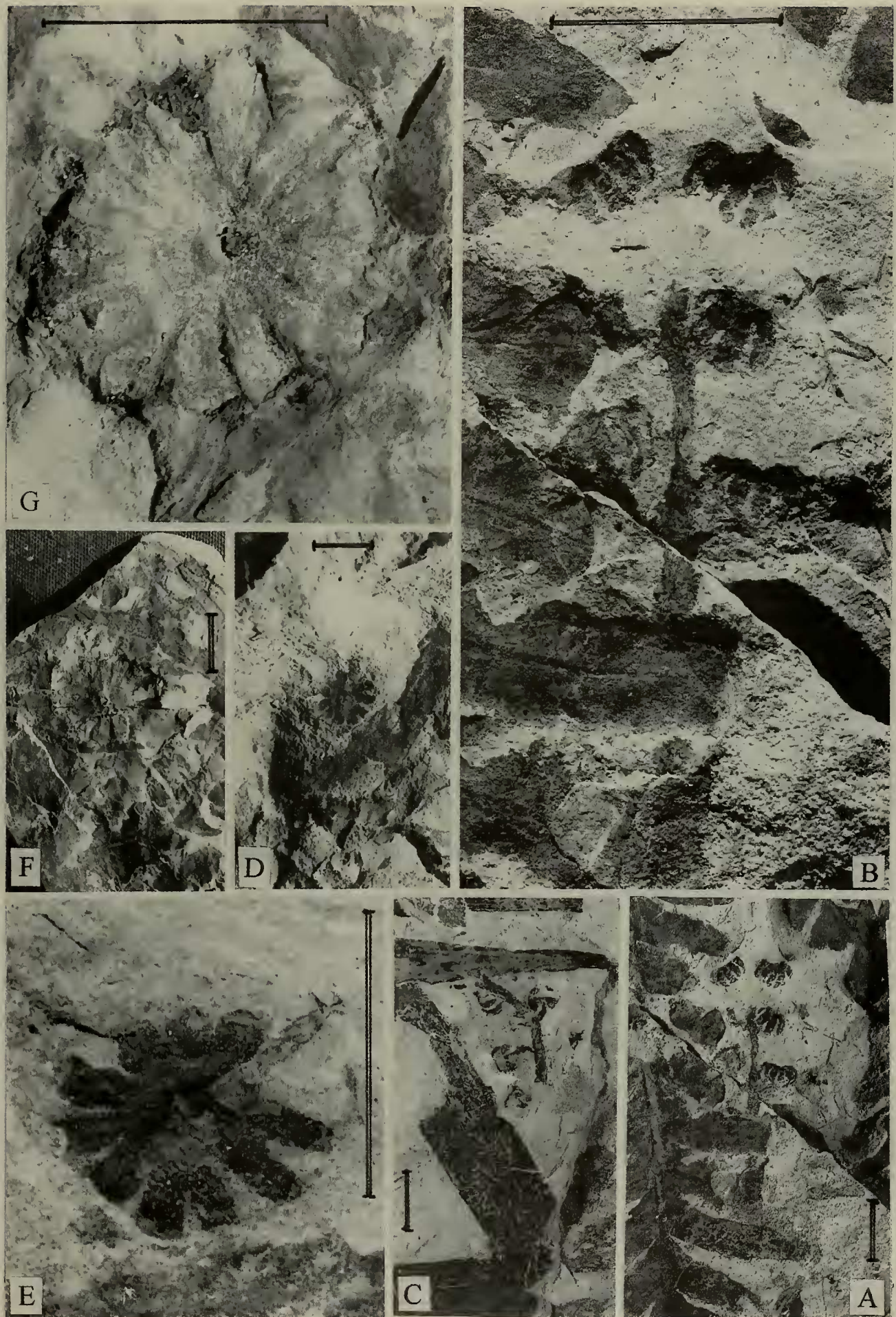


Figure 11. A-E. *Peltaspermum* cf *monodiscum*. A,B. AMF126824. C. AMF126825. D,E. AMF126826. F,G. *Peltaspermum* sp. A. AMF126852. All from Coal Mine Quarry. Scale bar = 1 cm.

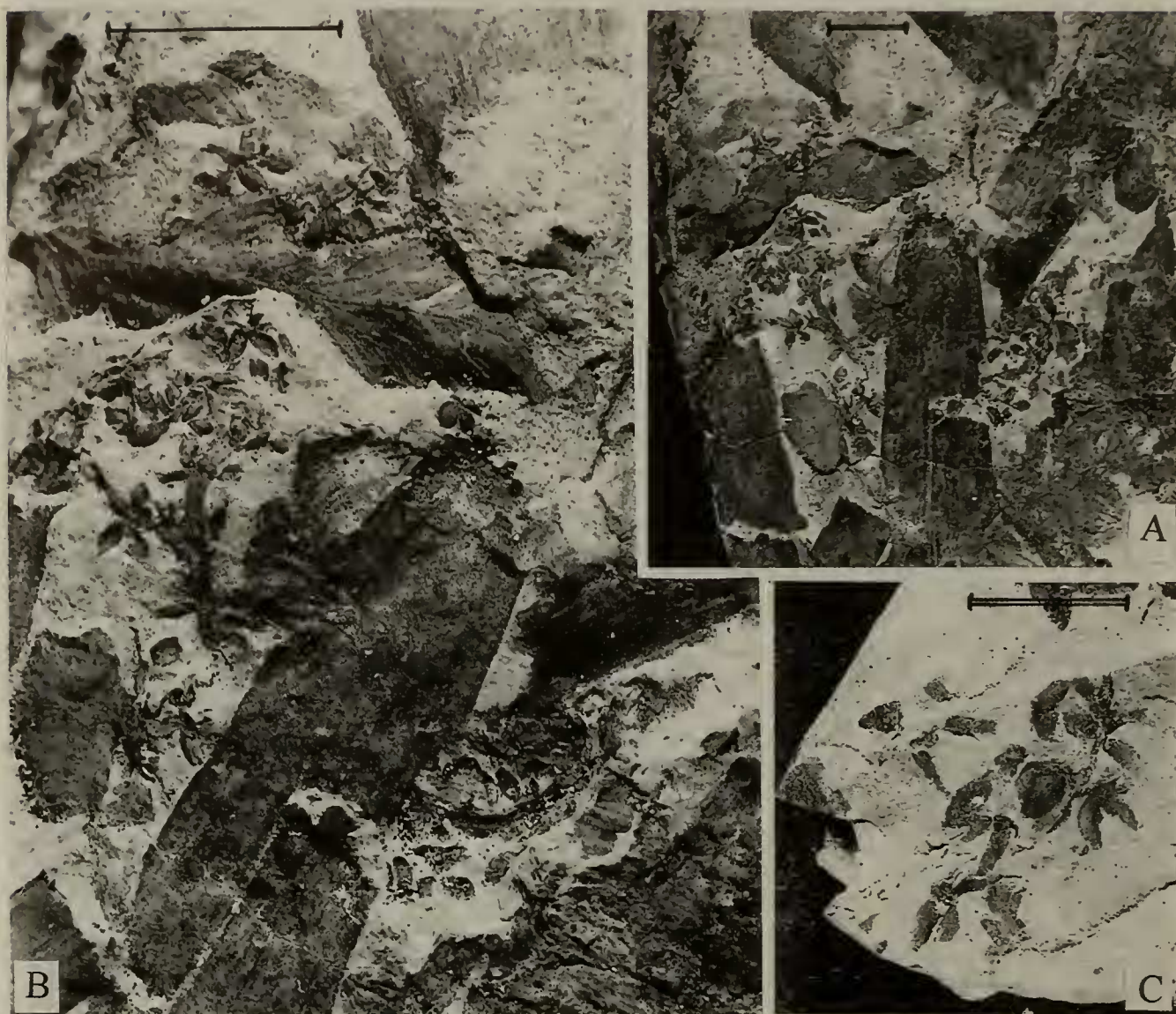


Figure 12. A-C. *Antevsia* sp. A. A,B. AMF126828. C. AMF126829. Both from Coal Mine Quarry. Scale bar = 1 cm.



Figure 13. A,B. '*Kutrziana brandmayri* complex'. A. AMF126830. B. AMF126831. Both from Coal Mine Quarry. Scale bar = 1 cm.



Figure 14. A-D. '*Kurtziana cacheutensis* complex'. A. AMF126832, showing venation. B. AMF126833. C. AMF126834. D. AMF126835. All from Coal Mine Quarry. Scale bar = 1 cm.



Figure 15. A. Leaf assemblage of '*Kurtziana cacheutensis* complex'. A. AMF126836. Coal Mine Quarry. Scale bar = 1 cm.

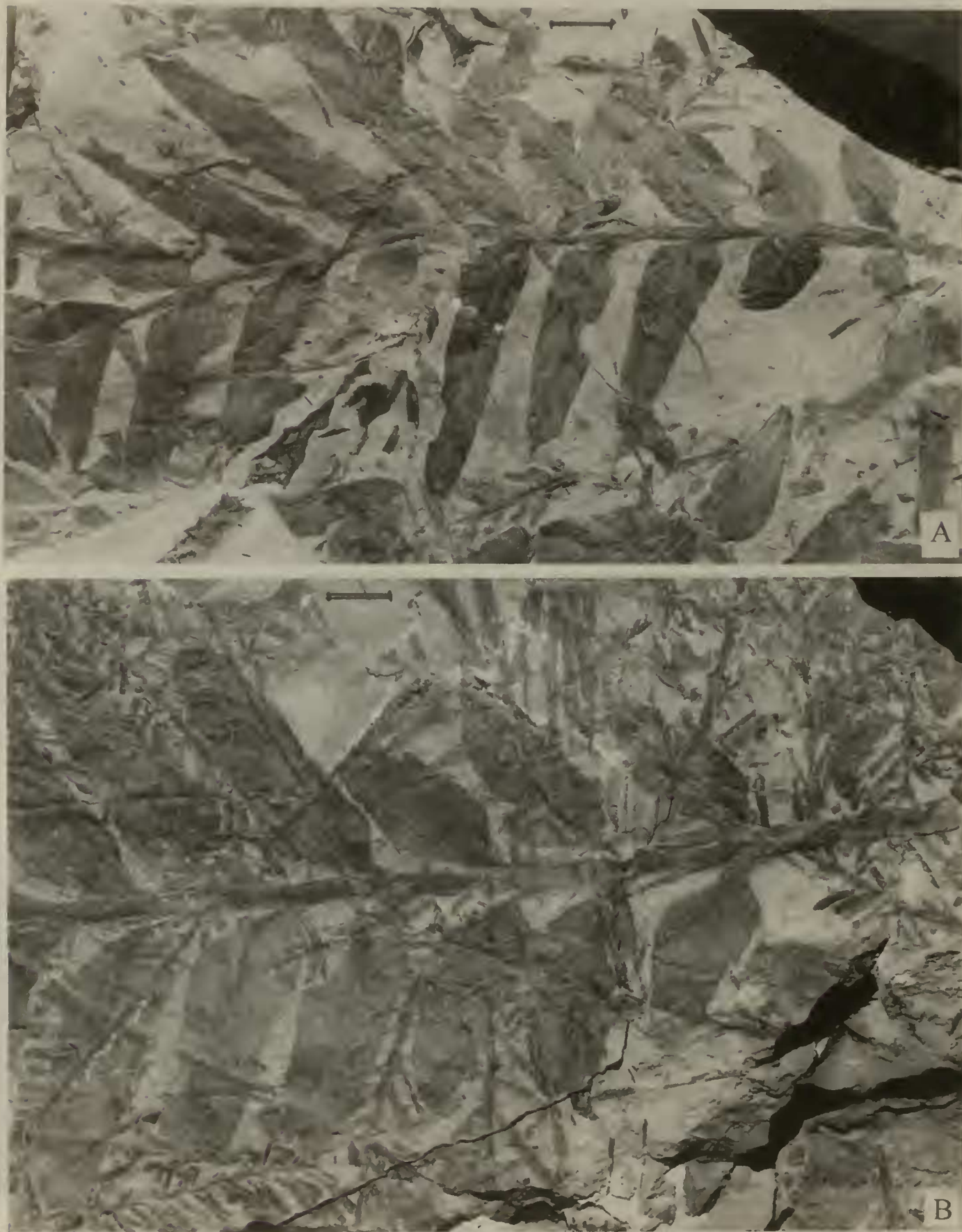


Figure 16. A,B. '*Kurtziana cacheutensis* complex'. A. AMF126837. B. AMF126838, leaf associated with *Rissikia* sp. Both from Coal Mine Quarry. Scale bar = 1 cm.

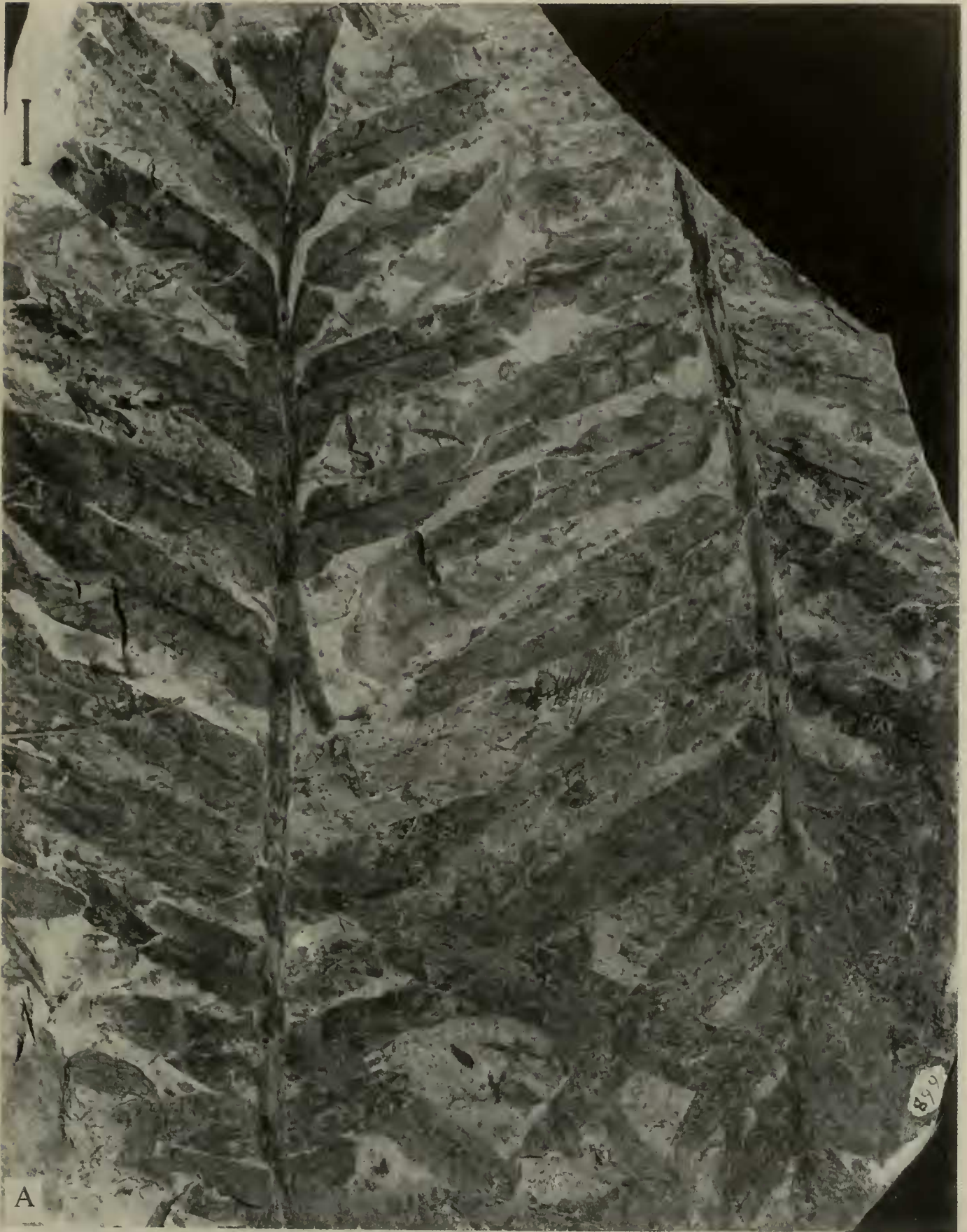


Figure 17. A. '*Kurtziana cacheutensis complex*'. AMF126839. Coal Mine Quarry. Scale bar = 1 cm.

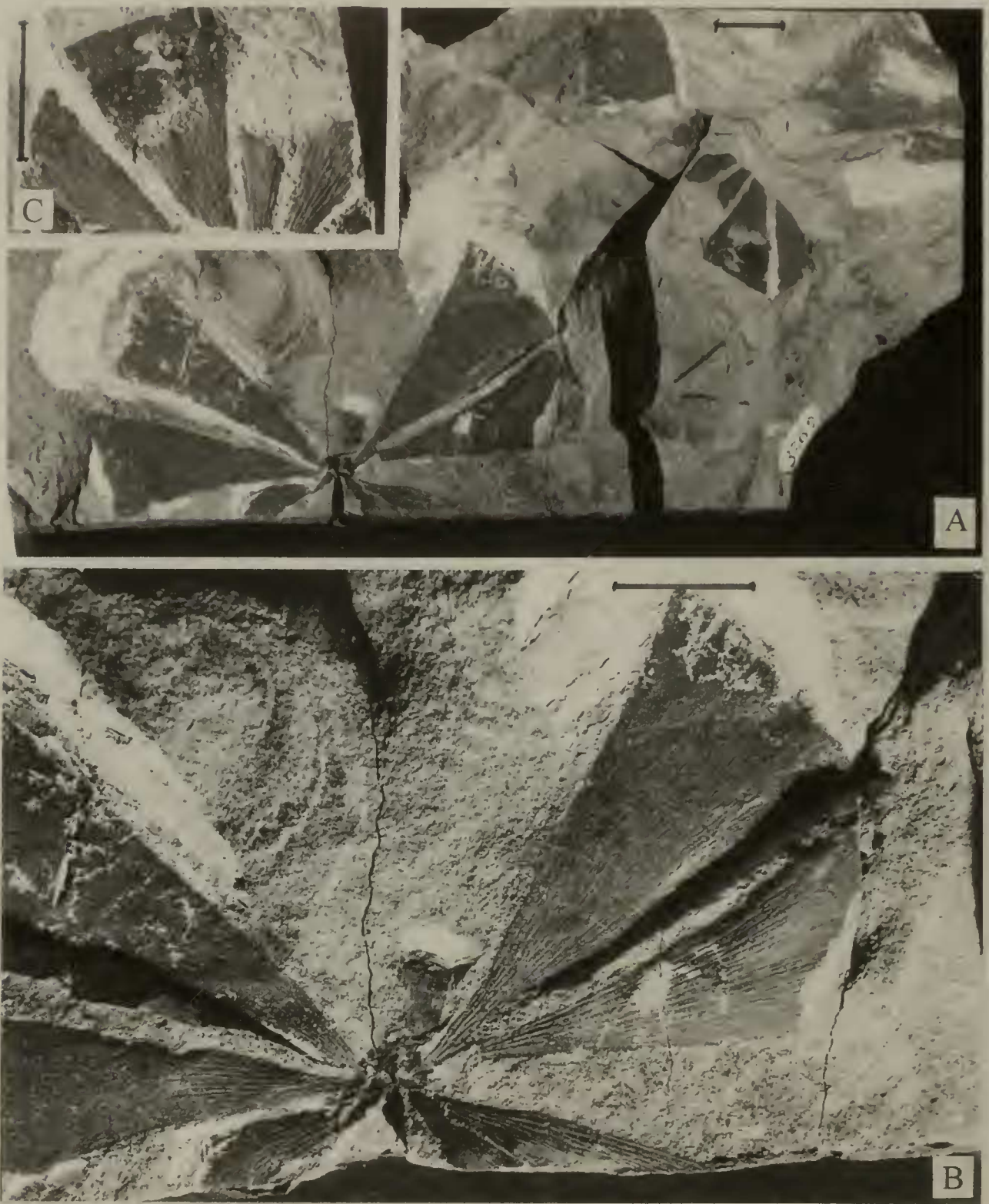


Figure 18. A-C. *Rochipteris obtriangulata* sp. nov. A. Portions of two whorls of leaves, AMF126840 holotype on left and AMF126841. B. AMF126840 and C. AMF126841 enlarged to show venation. Coal Mine Quarry. Scale bar = 1 cm.

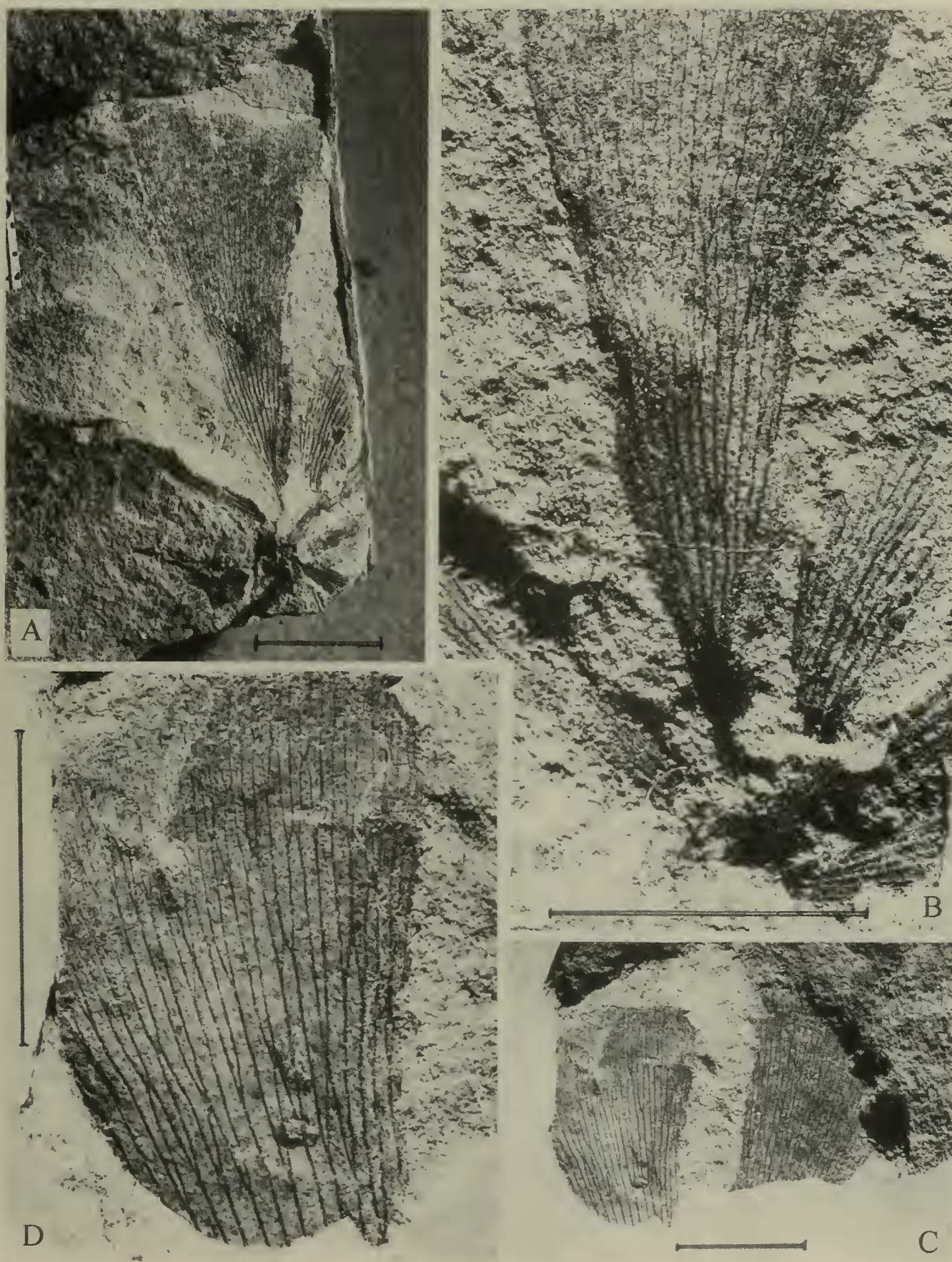


Figure 19. A-D. *Rochipteris obtriangulata* sp. nov., enlarged to show venation. AMF126842, counterpart of holotype. Coal Mine Quarry. Scale bar = 1 cm.

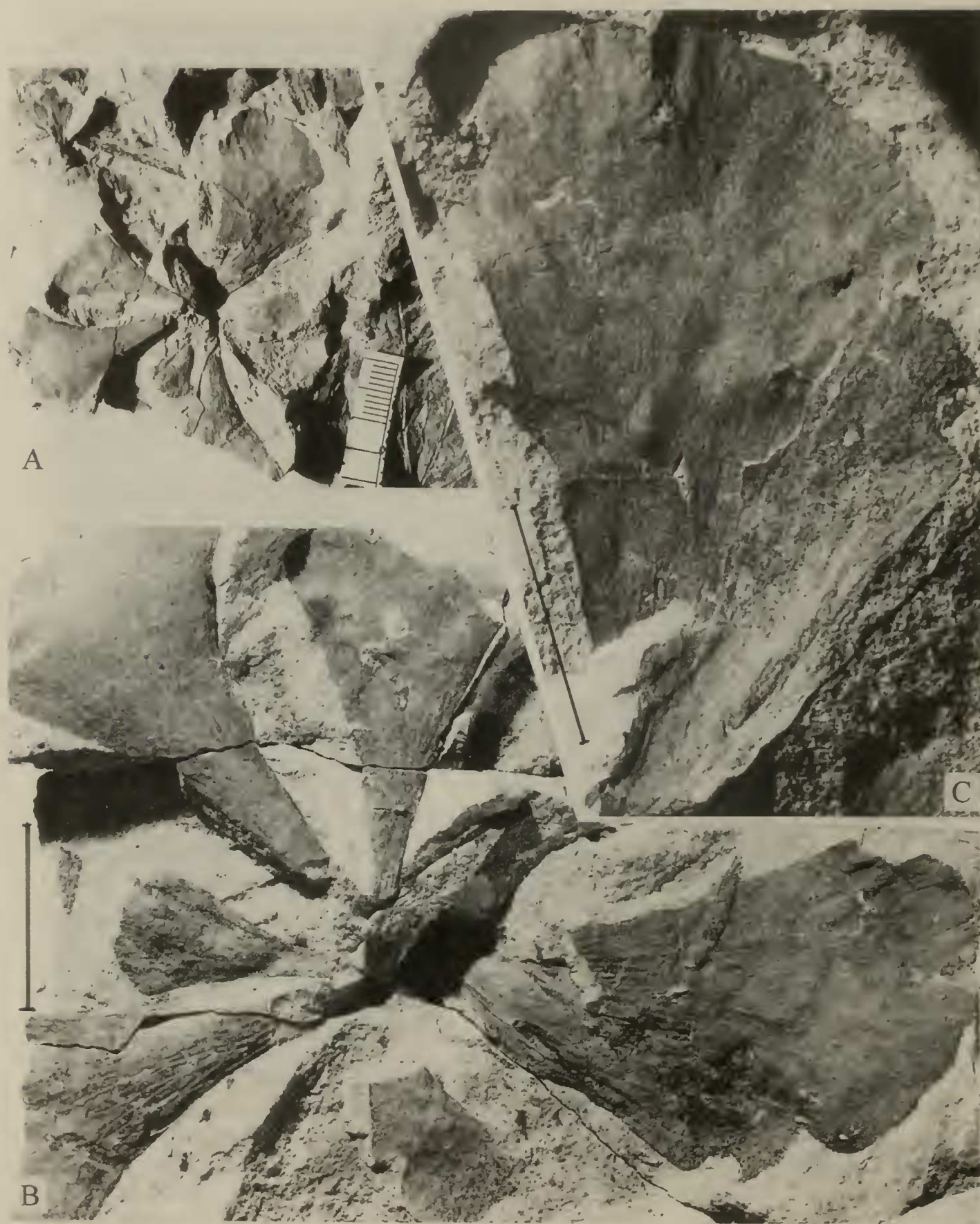


Figure 20. A-C. *Rochipteris tubata* sp. nov. Holotype. AMF126843. Coal Mine Quarry.
Scale bar = 1 cm.

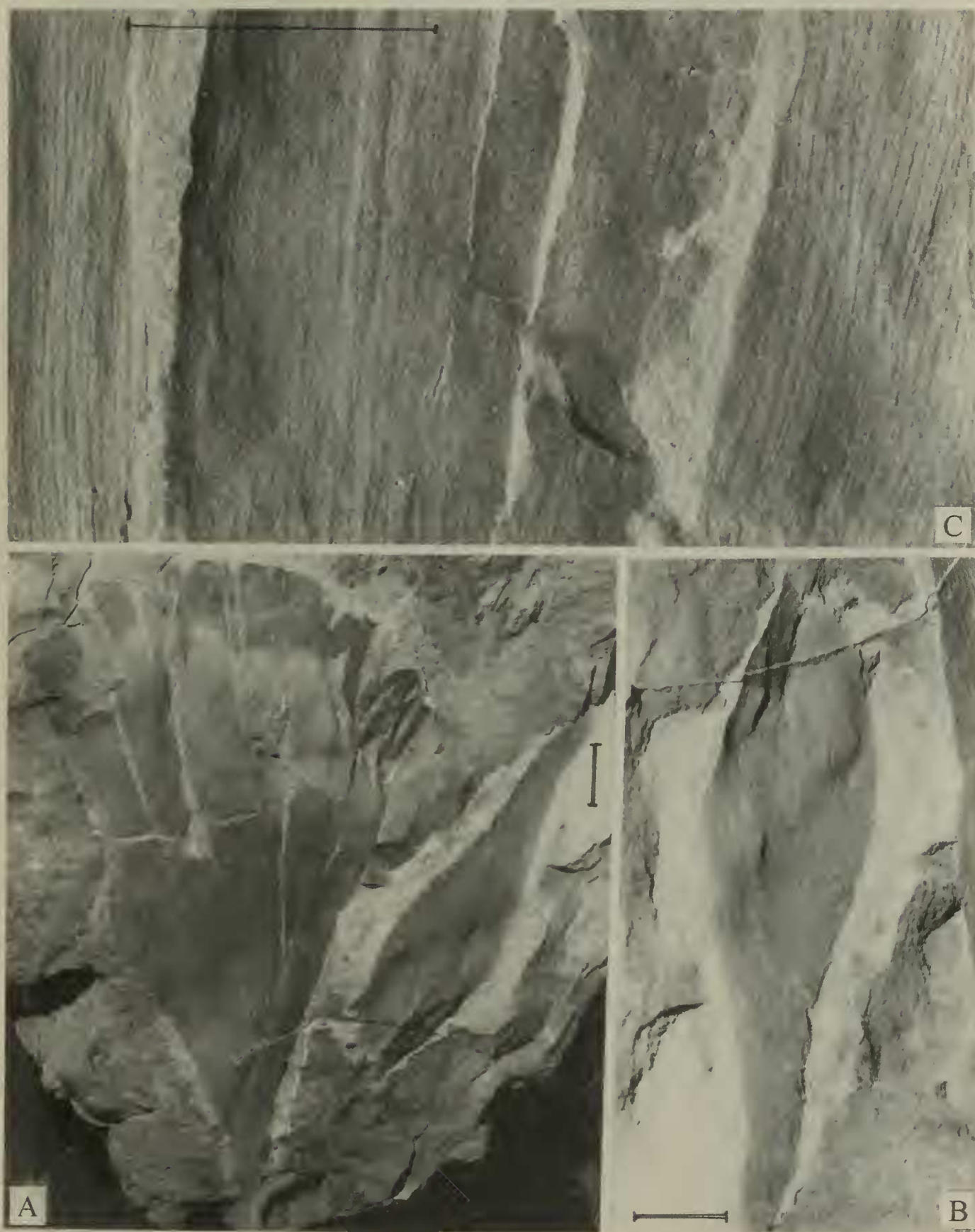


Figure 21. A. *Rochipteris incisa* sp. nov. Holotype on left, AMF126844, on right, AMF126827, juvenile leaf? B. AMF126827. C. AMF126844, to show venation. Reserve Quarry. Scale bar = 1 cm.



Figure 22. A. *Rochipteris incisa* sp. nov. Holotype. AMF126844. Reserve Quarry. Scale bar = 1 cm.



Figure 23. A-C. *Rochipteris sinuosa* sp. nov. Holotype. AMF126845. Coal Mine Quarry. Scale bar = 1 cm.

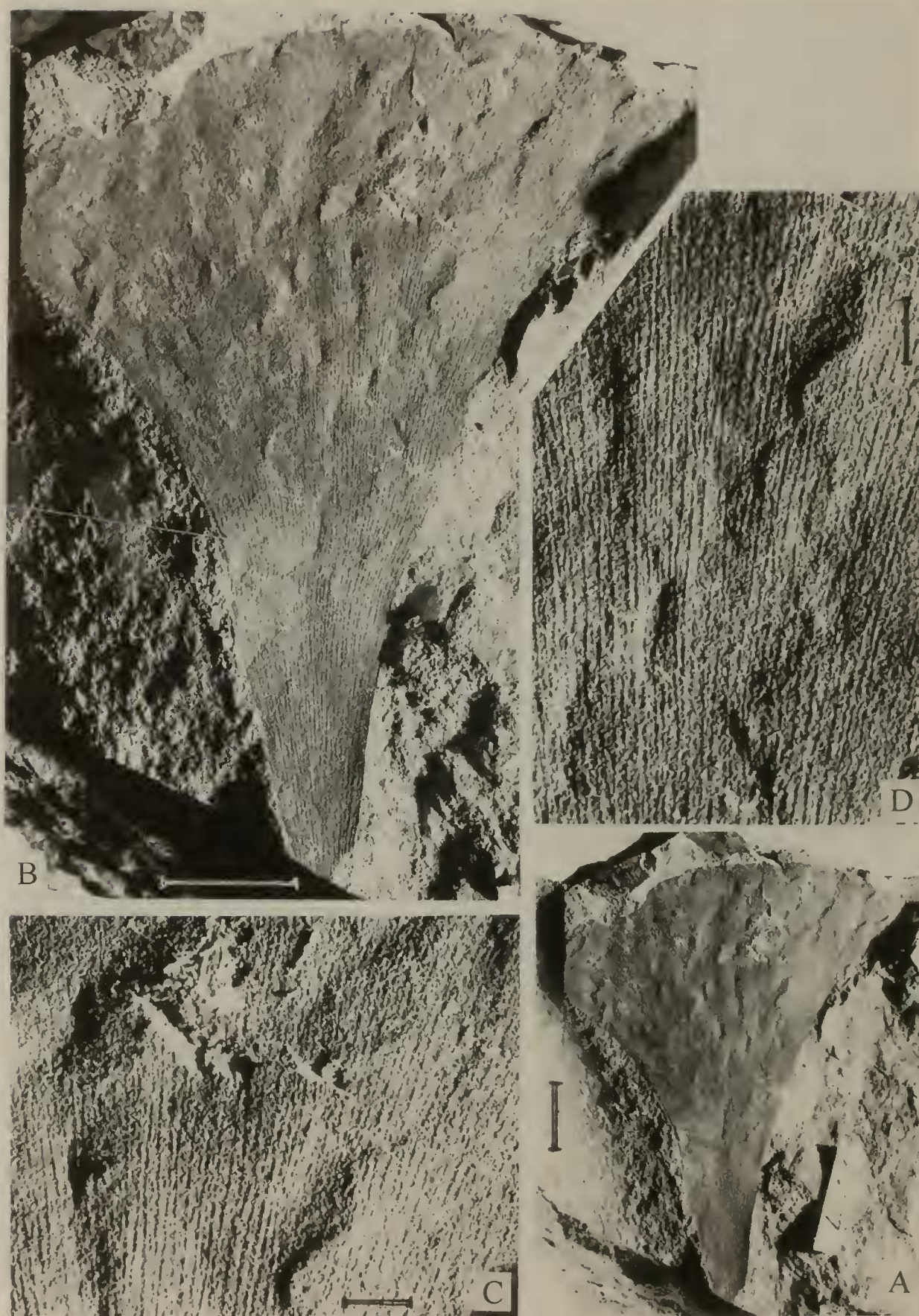


Figure 24. A-D. *Rochipteris nymboidensis* sp. nov. Holotype. AMF126846. Coal Mine Quarry. A and B, scale bar = 1 cm.; C and D, scale bar = 0.2 cm.

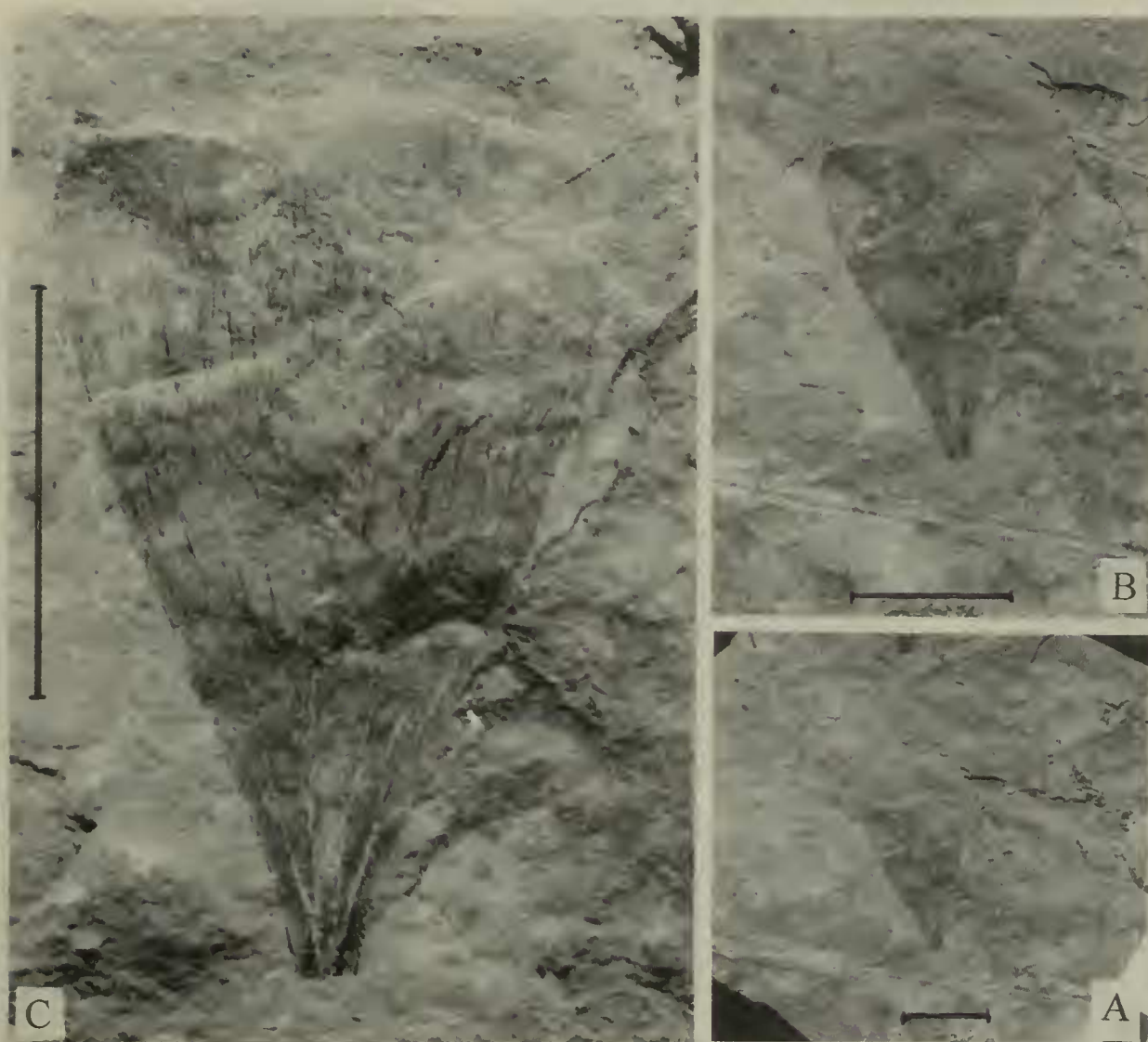


Figure 25. A-C. *Rochipteris pusilla* sp. nov. Holotype. AMF126854. Coal Mine Quarry. Scale bar = 1 cm.

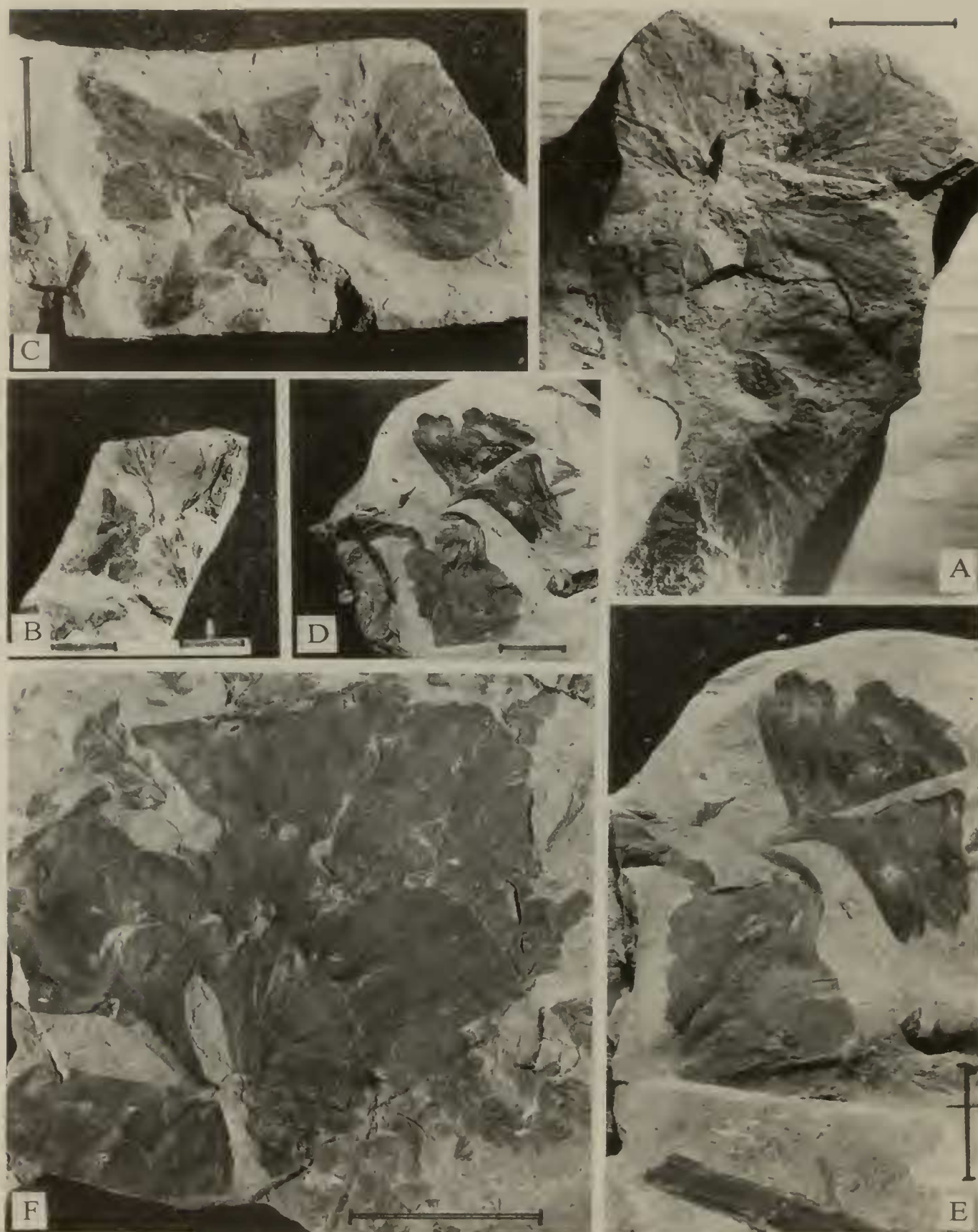


Figure 26. A-F. *Walkomiopteris eskensis* gen. et comb. nov. A. Holotype, QMF1729. Cutting near Ottoba railway station, Queensland. B. AMF113491. C. Counterpart of B. D,E. AMF113493. F. AMF113440. B-E. Reserve Quarry; F. Coal Mine Quarry. Scale bar = 1 cm.

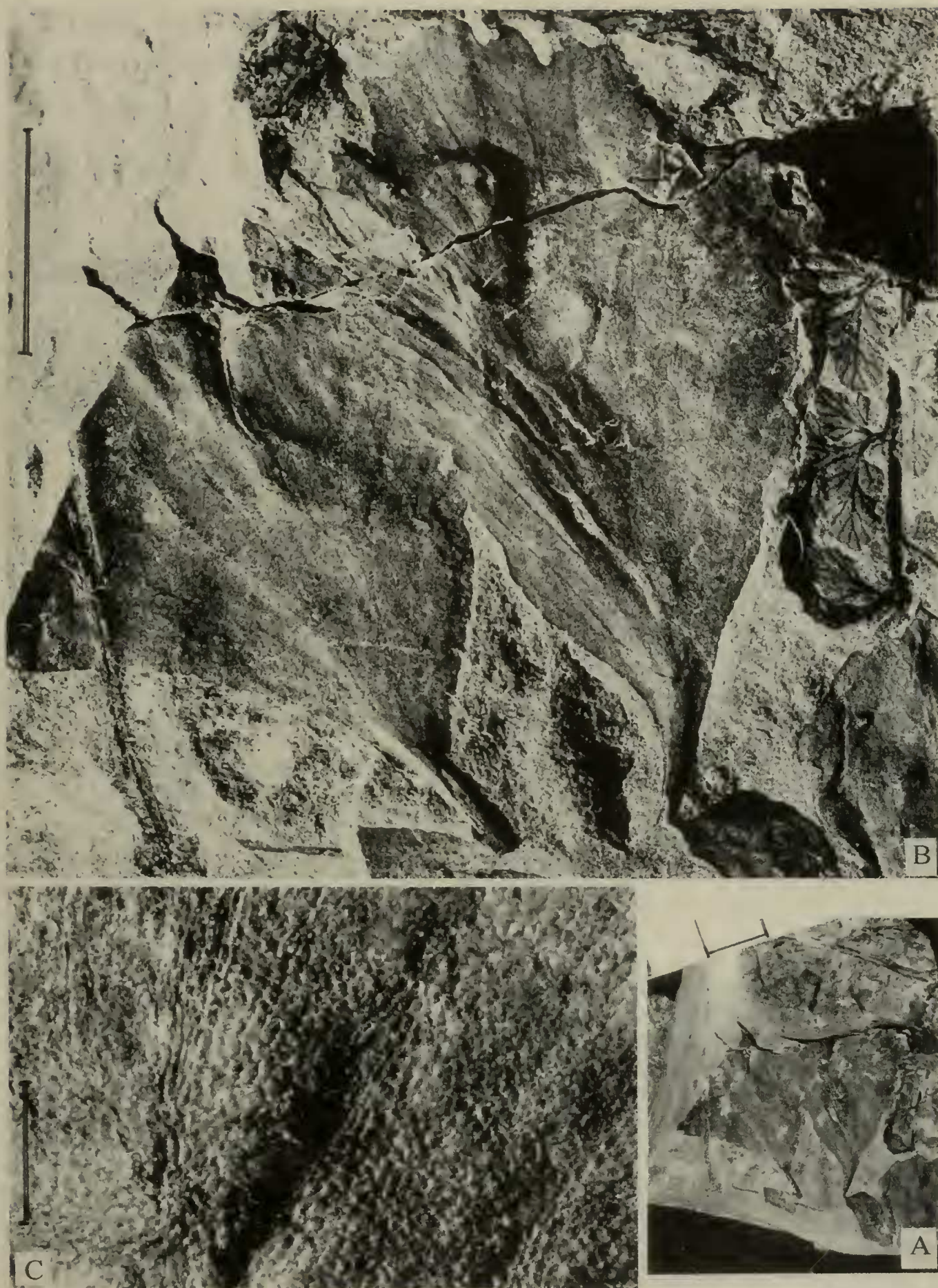


Figure 27. A-C. *Walkomiopteris eskensis* gen. et comb. nov. AMF113492. Reserve Quarry. A,B. Scale bar = 1 cm. C. To show cell structure. Scale bar = 0.1 cm.